

DISSERTATION

Submitted in Fulfilment of Requirements

for

EES817J Dissertation: Master of Education

PREDICTORS OF GRADE SEVEN MATHEMATICS ACHIEVEMENT

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October, 1985.

ACKNOWLEDGEMENTS

This study was possible because of the co-operation, assistance and guidance of many people, three of whom stand out as deserving of special mention.

Dr. Wayne Ransley, of the University of Tasmania, as my Programme Advisor, provided valuable assistance during this study, and encouragement and guidance throughout my post-graduate programme. His advice and support are very much appreciated.

Ms. Heather McLoughlin, Guidance Officer at New Town High School until 1984, provided valuable advice on guidance practices in primary and secondary schools, which contributed significantly to the overall direction of this study. Her support and provision of I.Q. and Reading Age data are gratefully acknowledged.

Mrs. Judy White, Guidance Officer at New Town High School, provided useful descriptions of the TOLA 6 and Standard Progressive Matrices I.Q. tests, and the GAP Reading Comprehension Test.

Special recognition is given to the many Grade Seven mathematics teachers, school administrators, teaching aides, and Grade Seven students of 1982 and 1983, who made possible the gathering of the data required for this study.

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ABSTRACT

The study investigated the predictive relationship between Grade Seven mathematics achievement and five intellectual variables: upper-primary school mathematics achievement, mathematics aptitude, non-verbal I.Q., verbal I.Q. and reading comprehension.

Subjects for the study were Grade Seven students from a secondary school. Data was provided by student measures on five test instruments which are widely used in primary and secondary schools as measures of academic ability.

Basic descriptive statistics, zero-order correlations and multiple linear regression techniques allowed for the exploration of several broad questions and issues that emerged from the review of related literature. The study investigated the following issues concerned with prediction of Grade Seven mathematics achievement:

1. that measures of prior mathematics performance are more efficient predictors than global performance measures;
2. that mathematics aptitude is a more efficient predictor than prior mathematics achievement;
3. that non-verbal I.Q. is a more efficient predictor than verbal I.Q.;

4. that where verbal I.Q. has already been included as a predictor then reading comprehension provides no additional predictive information.

Answers to these issues were generally consistent with previous research and were in agreement with theory. The following interpretation was made.

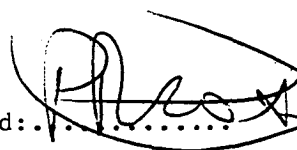
The two measures of prior mathematics performance were significantly more efficient predictors than the two measures of global performance. The measures of prior mathematics performance were not significantly different in predictive efficiency, nor were the global performance measures, but mathematics aptitude achieved the highest correlation, accounting for 56% of variance. Verbal I.Q. was a more efficient predictor than reading comprehension. The most efficient prediction was obtained by utilising both measures of prior mathematics performance and both measures of global performance. The four significant predictors together accounted for 66.06% of variance.

Using one-year cross-validation, a prediction equation was determined. The economic equation used both global performance measures and mathematics aptitude as predictors and achieved a cross-validated correlation coefficient of 0.78.

STATEMENT OF ORIGINALITY

This dissertation contains no material which has been submitted for examination in any other course or accepted for the award of any other degree or diploma in any university and, to the best of my knowledge and belief, contains no material previously published or written by another person except where due reference is made in the text.

Signed:.....



(P. R. Cox)

Date:.....

24/06/86

CHAPTER 1

STATEMENT AND DEFINITION OF THE PROBLEM

1.1 Introduction

School-based research into predictors of Grade Seven mathematics achievement is justified on three grounds.

Firstly, studies concerned with the prediction of early-secondary school mathematics achievement have largely failed to account for more than one-half of the criterion variance representing mathematics achievement, with most studies accounting for between one-quarter and one-half of the criterion variance. Dossey and Jones (1980), in their study of predictors of Grade Seven mathematics achievement, concluded that (educationally) significant predictors of routine computation skills, knowledge of mathematics concepts and ability to apply mathematics concepts, have yet to be found.

Secondly, Grade Seven is an important stage at which to study students' mathematics achievement. Transfer from primary school to secondary school, at the end of Grade Six, represents an important transition period in education because of the strengths and variety of influences experienced by students at this stage. Amongst these influences are the general broadening of the curriculum base, the specialization of curricula and the

need to choose curricula suited to potential career decisions. While learning success in mathematics is widely regarded as one of the corner-stones of intellectual development, such learning is also crucial to many career decisions and is an important pre-requisite for much of post-secondary school education. It is also true that a large proportion of secondary school students are perceived to be unsuccessful, or only marginally successful, in mathematics learning. This perception is reflected in continuing public concern about falling standards of mathematics skills and the debate concerning minimum-competency testing.

Thirdly, success in mathematics learning may be improved by secondary schools making correct decisions about ability groupings, class sizes, special curriculum offerings, remedial programmes and tutorial assistance. Improved decision-making by school administrators, guidance counsellors and teachers, concerning these school-situational factors, is possible if educationally significant predictors of mathematics achievement can be found. Such predictors may then be utilised to provide the necessary data concerning students' mathematics abilities so that, school administrators may better apply school-situational factors to those students for whom they were intended and, class group teachers may better plan the Grade Seven mathematics curriculum to overcome students' weaknesses and exploit their strengths.

1.2 The Purpose of the Study

In view of the current status of prediction studies of early-secondary school mathematics achievement, the purpose of this study is twofold:

1. to determine the predictive relationships between students' learning success in Grade Seven mathematics and a range of intellectual variables;
2. to determine an efficient and valid instrument, based on intellectual variables, with which to predict students' learning success in Grade Seven mathematics.

1.3 The Importance of the Study

Research into predictors of early-secondary mathematics achievement is important for practical and theoretical reasons. Herman and Gallo (1973) noted the practical importance of predictors of academic achievement, and the use made of prediction in secondary schools to assist the process of educational planning. Certainly teachers, school administrators, guidance counsellors and educational psychologists are dependent upon the results of this research

to properly fulfil their roles within the school. Theoretically it is reasonable to assume that educational research places particular value on the investigation of learning processes and their effects; hence the need for prediction of individual learning success and the identification of those intellectual variables which will reliably predict learning success.

1.3.1 Role of Predictive Validity

Much of the research into predictors of academic achievement is concerned with the predictive efficiency and long-term validity of intellectual tests (aptitude and achievement), dispositional variables (attitude and personality) and biographic variables (such as age, sex and socio-economic status), with multiple-regression analysis techniques being frequently employed to determine the relationship amongst the variables being studied. Nunnally (1970, p. 134), in discussing the uses of predictive validity studies, stated that "...in no other area is predictive validity as important as it is in using tests to help make decisions about schooling."

Research into the predictive validity of American college and university entrance tests is frequently reported in the literature. In addition to the established "admission tests" such as M.C.A.T., P.C.A.T. etc., the predictive efficiency and validity of "high school grade point average"

(H.S.G.P.A.) and the Scholastic Aptitude Test (S.A.T.), as predictors of college and university performance, is a continuing topic of research in this area.

Predictive validity studies, related to kindergarten and primary school, are also widely reported. Continued attempts, for substantial prediction of early school cognitive performance, are justified because of the need for early identification and remediation of conditions that may interrupt or interfere with later learning and school achievement.

The reasons for predictive validity studies of secondary school achievement are no less compelling, but such studies are less widely reported than similar studies at college/university or kindergarten/primary level. Herman and Gallo (1973) commented on the uses of prediction in secondary schools, particularly by administrators and counsellors. They concluded that predictive validity studies have assisted the process of educational and vocational planning by contributing to self-knowledge and to improved decision-making about schooling, and that such studies have produced instruments which may be used to predict readiness for grades, to divide children into levels of instruction, to select students for special programmes and to aid post-secondary school placement.

1.3.2 Choice of Predictors

The broadening of the curriculum base beyond primary school and the specialization of secondary school curricula have influenced the choice of predictors in studies of secondary school achievement. Global measures of aptitude and achievement, which are often perceived to be efficient predictors in college/university and kindergarten/primary studies, are generally too far removed from secondary school curricula to be efficient predictors of secondary school achievement. More efficient predictors include aptitude and achievement tests content validated for secondary school curricula, previous academic record, and school entrance tests.

Herman and Gallo (1973, p. 232) commented that "...there is much evidence to show that past academic achievement is the best predictor of future academic success". Morrison (1977, p. 43) noted that previous school record is well known to be the best single predictor of later school achievement. Davidson and Haffey (1979), in a study of secondary school achievement, found that prior academic performance was the best predictor of future academic performance. Certainly they are supported in this by numerous studies of academic achievement, ranging from primary school to tertiary level.

While previous academic record and global measures of

performance are often employed as predictors of future secondary school achievement, prediction studies have also taken into consideration dispositional and biographic variables. Many of these variables, being measures of attitude, personality, age, sex, socio-economic status, etc., are frequently employed as predictors of academic success when school systems are making decisions concerning allocation of resources between various schools or school districts. These variables are rarely important in prediction studies which deal with individual learning success.

1.3.3 Efficacy of Predicting Achievement

Much of the decision-making by school administrators is concerned with school-situational factors such as special curriculum offerings or different instructional situations. A great deal of research has been done on treatment-comparing prediction, which has answered questions related to the effects of different curricula and instructional methods on students with different learning requisites. Schwazer (1980, p. 195) noted that this type of prediction involves personal variables and variables of a situational nature which answer the question as to which students are especially successful under what types of learning conditions. Such an "aptitude - treatment interaction" (ATI) model provides predictive information for an individual with a specific set of personal, predictor variables for which at least two estimates of criterion variables are

available - one estimate for each instructional situation or different curriculum offering - so that a placement strategy can be attempted on the basis of the higher predicted criterion score.

Schwarzer (1980, p. 196) also noted that "...in actual educational practice, treatment-comparing prediction has not yet proved its worth sufficiently", despite numerous studies of aptitude - treatment interactions which have determined significant outcomes resulting from different curricula or instructional methods. This may be so because schools are often faced with difficulties in implementing the results of such research: research samples, conditions and outcomes are sometimes vastly different from those existing in the school; identifying students' learning requisites so that placement strategies can be attempted is often regarded as too time-consuming; schools often lack valid, locally acceptable measure of students' abilities, measures which are highly related to the criteria of interest. Such measures would allow school administrators and teachers to determine students' learning requisites in important areas of curricula, and hence, make decisions for students concerning the range of school-situational factors which are known to affect learning success in these areas.

Decisions involving preventive intervention of remedial or tutorial programmes require a "risk" prediction which

identifies students with a low likelihood of success due to handicaps or learning difficulties. The "at risk" students' characteristics, which are predictors of low achievement or learning difficulties, are identified. A programme of preventive intervention, which counteracts the negative cause of development, is then derived from the predictive model.

By and large, prediction studies of early-secondary school achievement have not taken school-situational factors into consideration in formulating model equations; only global aptitude and achievement variables, and perhaps dispositional and biographic variables, were considered. The resulting multiple-regression correlation coefficients were quite low, so that usually less than one-half of criterion variance was accounted for, and often as little as one-quarter was accounted for, and this only when a multitude of predictors was used.

Schwarzer (1980) comments on the consequence of this approach:

"... the decisive weakness of the model within the framework of educational predictions lies in a blindness as to treatment. It is implicitly assumed that there is a valid theory about the conditions of learning outcomes, excluding situational determinants in the learning process. This is the reason why the predictability of the criterion is limited right from the start. The quality of instruction as a future treatment effect can and should have considerable influence on the learning outcome in order to invalidate failure predictions."

It is therefore arguable that if prediction models use intellectual, dispositional and biographic variables only, then a low multiple-regression correlation coefficient is to be expected if organizational, instructional and treatment variables have had their intended effect on students' performance. But, if the situational variables are then included as predictors in the model equation, the multiple-regression correlation coefficient should rise significantly, so that a substantial portion of the criterion variance is accounted for by the model equation.

However, while the quality of instruction should be a major determinant of learning success, its effect in lower-secondary school may well be diminished in areas of school curricula where substantial foundation knowledge already exists. Such an area is Grade Seven mathematics, where prior school and non-school effects have contributed to give beginning Grade Seven students extensive mathematics backgrounds. Indeed, a prediction model utilising intellectual variables alone may substantially predict students' learning success in Grade Seven mathematics, and thus achieve an acceptably high multiple correlation coefficient.

Morrison (1977), in the concluding statement of his prediction study of achievement in secondary schools, contends that differences amongst schools suggest that the school rather than the school system is the appropriate unit to examine in

prediction studies. Certainly this brief examination of the uses of prediction and the efficiency of prediction studies supports Morrison's contention: the school is primarily responsible for the learning environment; the learning environment must reflect students' learning requisites; students' learning requisites must be reliably measured so that appropriate placement strategies can be implemented.

1.4 The Tasmanian Experience

1.4.1 The Education System

In Tasmania, attendance at school is compulsory for all children from the age of 6 to 16 years, whether they are enrolled in a state-controlled school or in a private school.

The state-controlled system also supports non-compulsory kindergarten education: children may commence their early childhood education by attendance at pre-primary, kindergarten classes. Such classes may form a separate kindergarten school, or they may be linked to the infant classes of a primary school.

This stage of early childhood education is followed by a six-grade primary school which, is a separate school in its own right or, forms the first six years of a much larger ten-grade district high school.

Following six years of primary schooling, students proceed to secondary education, of which the first four years may either be completed in a district high school, or in a high school. Beyond the tenth grade, students may attend a technical college on a full-time or part-time basis, or a secondary college where they may complete the final two years of secondary schooling.

In the Tasmanian education system, the transition from primary school to secondary school takes place at the end of the Grade Six year. Grade Seven is the beginning year of secondary school for all students, whether they are enrolled in a state-controlled school, or in a private school.

1.4.2 Transition from Primary to Secondary School

For many students the transition from primary school to secondary school is unnecessarily segmented. Students find that teachers, styles of teaching, record keeping, testing procedures, administrative requirements and location of buildings change abruptly as they move from Grade Six to Grade Seven and, at the same time, that unnecessary repetition and lack of coordination occurs between primary school curricula and secondary school curricula.

On the other hand, many schools do smoothly manage the transition from primary school to secondary school. Where the

transition is smooth and well-organized there are usually several factors at work: continuity in administrative practices and school philosophy; joint planning of curricula by teachers from both sides of the transition point; an effort to provide a continuous and graded education for all students throughout the ten years of primary and secondary schooling; opportunities for teachers to teach at various stages on both sides of the transition point.

In only one area of the state-controlled system are these factors built into the organisation of schools: district high schools, where education is provided for students from kindergarten to tenth grade within the one institution. Since all grades are contained within the school it is possible to plan students' education as a single sequence by providing continuity in philosophy, administration, and curricula.

1.4.3 Consequences of a Lack of Continuity

In high schools, the beginning year of secondary education is often characterized by a lack of continuity with the final year of primary school; curricula, philosophies, administrative procedures and school sizes are sometimes vastly different. In addition, secondary school teachers and primary school teachers are trained differently, their appointments are usually made by different authorities, their career expectations lie within their own divisions, and rarely do they

have any teaching experience outside the stage of schooling represented by their own division.

Often the lack of continuity from primary school to secondary school is reflected in the paucity of performance data on students entering high schools, so much so that, in many areas of high school curricula, guidance counsellors and school administrators are frequently unable to make informed decisions for students, early in the beginning year of secondary schooling, about school-situational factors such as class sizes, ability groupings, remedial programmes, special curriculum offerings, and tutorial assistance.

1.4.4 Testing Academic Performance

At the present time, it is unusual for high schools to receive detailed information from primary schools on the progress of students during the latter part of primary schooling. However, it is Education Department policy that students in state-controlled primary schools be tested in the areas of verbal I.Q. and non-verbal I.Q. during the latter part of the Grade Six year.

These tests, usually carried out by high school guidance counsellors, are often of little real value to high school administrators and teachers. While global academic performance measures have enabled high school guidance

counsellors to classify beginning students according to general academic ability (high ability, average ability, and low ability), many such students have been found to not perform at the same level of academic ability in all areas of the Grade Seven curriculum.

This effect, combined with the general broadening of the curriculum base from Grade Six to Grade Seven and the specialization of secondary school curricula, together with the need to allocate limited secondary school resources to those students most in need, has compelled high schools to undertake the testing of Grade Seven students, in specific areas of curriculum, to provide performance data upon which high school guidance counsellors, administrators and teachers may make informed decisions about school-situational factors.

One recent decision concerning such testing has resulted in high school guidance counsellors testing primary school students for reading comprehension during the period of time when I.Q. tests are normally conducted with these students. The results of the reading comprehension test are used to allocate students to remedial reading groups at the beginning of the Grade Seven year.

Indeed, testing of "core" curriculum areas for all students by the beginning of Grade Seven is important so that they may gain the advantage of early decisions concerning class

size, ability groupings, remedial programmes and tutorial assistance, in these areas.

1.5 The School

The present study is sited at New Town High School, a high school in which decisions by guidance counsellors, school administrators and teachers, concerning the beginning year of secondary school, are based on limited information made available by "feeder" primary schools. That many of these decisions are ultimately shown to be correct decisions is a tribute to the experience of the decision-makers, particularly in interpreting I.Q. data on students, and the effectiveness of their counselling procedures.

New Town High School, located in southern Tasmania in the city of Hobart, is the only state-controlled all-boys day and boarding school in Tasmania. Nearby, is an equivalent all-girls day and boarding school. Together, these two schools accept students from feeder primary schools in their immediate neighbourhood, and students from "out-of-area" primary schools in the surrounding districts.

1.5.1 Organization and Curriculum

New Town High School is organized along traditional lines with students being placed into one of the four grades,

and then into class groups within the grade. Curricula is generally the responsibility of subject departments, with teaching being done by specialist teachers in the subject department. The School offers the usual school subjects, with English, Mathematics, Science and Social Science being part of the curricula of all students, while a range of other vocational and academic subjects are offered as options. Additionally, there are two special education classes for learning-deficient students, remedial teaching and work in careers education.

Mathematics education at New Town High School is organized into two separate courses of study, known as Mathematics and Advanced Mathematics, according to the curriculum requirements of The Schools Board of Tasmania, a State Government appointed authority with responsibility for curriculum content and standards. The first course, Mathematics, is divided into three levels of difficulty for Grades Eight, Nine and Ten, with students studying at one of the three levels. However, in the beginning year of secondary school, students do not study this course at one of the three levels but, instead, all Grade Seven students study a "common" course. The second course of study, Advanced Mathematics, is available only to students in Grades Nine and Ten as an option, and is offered as a more demanding curriculum in mathematics to more able students.

1.5.2 Improving Mathematics Teaching at the School

Global performance measures, such as tests of verbal and non-verbal I.Q., have not in the past provided useful data about beginning students' strengths and weaknesses in mathematics. Guidance counsellors, school administrators and teachers acknowledge the deficiencies of existing sources of data concerning students' prior mathematics performance and learning requisites in mathematics. Mathematics achievement and mathematics aptitude tests, undertaken at the end of Grade Six or the beginning of Grade Seven, may provide the necessary data concerning students' mathematics abilities so that, school administrators may better apply school-situational factors to those students for whom they were intended and, class group teachers may better plan the Grade Seven mathematics curriculum to overcome students' weaknesses and exploit their strengths.

1.6 Summary

In summary, the rationale for this study rests upon the following.

1. The knowledge of which variables substantially predict Grade Seven mathematics achievement is of potentially great significance to educators since prediction of individual learning success in mathematics may lead to greater understanding of the learning processes involved, and their effects.

2. The determination of an instrument with which to predict Grade Seven students' mathematics achievement, based upon significant intellectual variables, would provide a particularly useful tool for school administrators and Grade Seven mathematics teachers. The paucity of performance data for beginning students has contributed substantially to the lack of continuity from primary school to secondary school: secondary school administrators are often unable to make informed decisions for students concerning a variety of school-situational factors, which include ability groupings, class sizes, remedial teaching; teachers are unable to properly plan their teaching because of poor knowledge of students' mathematical backgrounds.

CHAPTER 2

REVIEW OF RELATED LITERATURE

2.1 Introduction

The body of literature available to the investigator of school mathematics achievement is indeed vast. With the multivariate nature of mathematics achievement well established, predictive validity studies and studies concerned with specific predictors of school mathematics achievement are continuing themes in the literature but, few studies report research into predictors of school mathematics achievement where such predictors are related to individual learning success and, few studies are concerned with the beginning year of secondary schooling.

In recent years, a small number of studies have been reported which have been concerned with the predictive efficiency and validity of predictors of school mathematics achievement at the upper-primary/lower-secondary school stage. These studies, employing a variety of intellectual, dispositional, and biographic variables as predictors, have had mixed success.

The results of several studies reviewed in this chapter demonstrate the comparative importance of the intellectual,

dispositional and biographic domains of measurement to the prediction of learning success in Grade Seven Mathematics achievement. Within the intellectual domain, the comparative efficiency of predictors closely related to the criterion, and global performance predictors is a major purpose of the review. A review of other studies will support the notion that a economic set of efficient intellectual predictors, rather than any one predictor, will provide the best estimate of students' mathematics abilities.

2.2 The Comparative Importance of Domains of Measurement

The domain of measurement from which predictors are drawn has an important bearing on the success of predictive validity studies of lower-secondary school mathematics achievement.

Dossey and Jones (1980) used intellectual variables obtained at Grade Three and Grade Five to predict students' individual learning success in Grade Seven mathematics. In particular, multiple regression analysis was employed to determine the combinations of the computation, concept, and applications subsets of the Stanford Achievement Tests and the Otis Lennon Mental Ability (I.Q.) Test which best predicted achievement on each of the three mathematics sub-tests of the Stanford Achievement Tests at Grade Seven.

Their results (TABLE 2.1, p.23) showed that I.Q. was the best single predictor of the Grade Seven "concepts" test, while the Grade Seven "computation" and "application" tests were best predicted by the corresponding tests at Grade Five. None of the best single predictors accounted for more than one-half of the variance of its criterion variable, but multiple regression analysis of the variables using Grade Three and Grade Five I.Q., concepts, computation and application tests as predictors did account for marginally more variance: R-SQUARED ranged from 0.52 to 0.60.

Dossey and Jones concluded from their study that significant predictors of routine computation skills, knowledge of mathematical concepts, and ability to apply mathematical concepts, have yet to be found. Their results must cast doubt on the efficacy of I.Q. and mathematics achievement tests, obtained at Grade Three and Grade Five, as predictors of lower-secondary school mathematics achievement. The correlations between the aptitude and achievement tests scores show that the Grade Seven computation and concepts tests were better predicted by the Grade Five computation and concepts tests than by the Grade Three computation and concepts tests.

This result is not unexpected given maturational and educational influences on students' intellects during the period of time from Grade Three to Grade Seven. Prediction

studies of students' achievement must always recognize the importance of the temporal relationship of predictors to the criterion: that is, if all other effects are constant, measurements of criterion variables and predictors closely related in time will produce higher correlations, than will measurements between criterion variables and predictors more removed in time.

Guerriero (1979), in a study of Grade Eight mathematics achievement, employed dispositional and biographic variables as predictors of both school mean achievement in mathematics and individual student mathematics achievement. From TABLE 2.2, p.25, it may be seen that none of the predictors used by Guerriero to predict individual learning success in mathematics accounted for more than 12% of the criterion variance. Guerriero noted in his report that the non-manipulatable, biographic variables (sex, family size, race, socio-economic status) were not as powerful predictors (of individual student learning success) as the manipulatable, dispositional variables (student perception of parental expectations, student educational expectations, self-esteem, student perception of teacher expectations), and even these variables did not correlate substantially with individual learning success (<0.34).

Guerriero was more successful in predicting of mean school Grade Eight mathematics achievement, with predictors

TABLE 2.2Correlations Between Predictors and Individual Student
Mathematics Achievement(Guerriero, 1979; p. 72)

Student Perception of Parental Expectations (0.34)
Student Educational Expectations (0.32)
Self-Esteem (0.29)
Amount of Formal Education of the Parents (0.26)
Student Perception of Teacher Expectations (0.25)
Amount of Reading Material in the Home (0.23)
Parental Interest in School (0.21)
Occupations of Parents (0..21)
Race (0.17)
Amount of Television Viewing (-0.15)
Family Size (-0.13)
Stability of Student Residence (0.13)
Accessibility of the Library (0.09)
Number of Older Brothers and Sisters (0.08)
Amount of Time Spent on Homework (0.05)
Sex: Boy or Girl (0.01)

accounting for between 3% and 40% of variance in the criterion. On the basis of measured correlations, predictors employed in the study were better suited to predicting mean school achievement than individual student achievement.

Guerriero concluded that teaching behaviors involving increased positive reinforcement, encouragement, and overt concern for students are of paramount importance. Additionally, where parents are supportive of the school, individual student performance tends to be high.

Guerriero's study largely confirms the established belief amongst teachers of the importance of manipulatable, dispositional variables (students' attitudes). That the correlations between the criterion representing mathematics achievement and the dispositional variables are low (0.34), is not an indication of lack of educational significance of the dispositional variables. Rather, it reflects the limitations of measures of attitudes and personality, and the data analysis technique used by Guerriero. Unless his measures of personality and attitudes both reflect the same underlying determinants of mathematics achievement, multiple regression analysis may well have produced more substantial results than simple correlation coefficients. A model equation determined by multiple regression would include each of the dispositional variables, weighted and summed, to account for the largest possible amount of variance in the criterion.

Guerriero concludes by saying:

"Changing attitudes rather than changing materials may be the key to improving mathematics achievement".

As this study stands, low predictive efficiency of each of the dispositionbal variables is its major weakness. Hence, Guerriero's conclusion is tenuous.

Youngman's (1978,1980) studies of transfer effects from primary school to secondary school provide some insight into the comparative importance of intellectual, dispositional and biographic variables as predictors of lower-secondary school mathematics achievement. Youngman (1980) found that intellectual variables correlated strongly with secondary school performance variables. Most of the dispositional variables also showed significant correlations with secondary school performance variables, while correlations between the biographic variables and performance measures were uniformly low.

In TABLE 2.3, p.28 , the criterion variable measuring lower-secondary school mathematics achievement SMAT correlated strongly with three upper-primary school intellectual variables: mathematics achievement JMAT (0.80); non-verbal I.Q. JNVR (0.68); reading comprehension JRED (0.62). These results are substantially better than similar results presented in the

TABLE 2.3

Correlation Matrix for City Sample(Youngman, 1980; p. 47)

		J	J	J	J	J	J	J	S	S	S	S	S	S	S	J	J	J	S	S	P	P	
A	S	A	A	A	S	S	S	M	A	A	A	S	S	S	S	M	N	R	M	R	M	R	P
G	E	S	P	P	C	C	C	O	S	P	N	C	C	C	O	V	E	A	E	A	E	A	
E	X	S	S	H	S	P	A	T	S	S	X	S	P	A	T	R	D	T	D	T	D	T	
3	4	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	
3	-	03	11	07-06	05-03	01-02	10-02-04	13	09	03	10-10	10-01	07-01	00	00								
4	-	-02	24	17-15-02	00	21	10-09	15-10-06	00	14	12	24	11	14	06-04-03								
6	-	-13-35	13	14	16	05	10-02-14	02	09	08	08-08	04-02	04	01	02	03							
7	-	06	12	21	31	42	15	14	07	01	09	16	21	20	26	24	24	26	08	12			
8	-	-11-31-32	00-12	02	32-13-21-16-10-10-12-18-12-18-05-07																		
9	-	43	33	07	14	08-09	38	16	16	05	06	00	08	03	09	05	05						
10	-	41	30	14	04-13	21	33	17	14	21	30	22	28	29	09	20							
11	-	41	24	02-17	16	17	44	31	24	24	25	18	26	03	11								
12	-	29-06-05-04	13	31	54	26	32	29	29	30	10	13											
13	-	-41-23	13	13	46	52	05	08	10	10	09	06	03										
14	-	27	04-01-19-20-04-02-05	00-02	02	02																	
15	-	-16-20-34-20-11-14-17-12-16-03-06																					
16	-	38	20	05-05	04-02-05-02-11-01																		
17	-	26	13	17	11	14	05	20-03	14														
18	-	52	31	22	30	13	25-04	04															
19	-	16	25	21	27	24	13	13															
20	-	49	72	46	66	17	20																
21	-	64	69	63	00	23																	
22	-	61	73	22	00																		
23	-	70	72	37																			
24	-	36	68																				
25	-	29																					
26	-																						

Notes

1. Decimal points are omitted from correlation coefficients.
2. Values greater than +14 or less than -14 were significant.
3. Variable domains are: biographic (2, 3); dispositional (6 - 19); intellectual (20 - 26)

Dossey and Jones (1980) study, and two conclusions may be drawn from their comparison.

Firstly, Youngman's (1980) criterion correlated more strongly with upper-primary school mathematics achievement than with upper-primary school non-verbal I.Q., thus demonstrating the importance of choosing predictors which closely measure the same performance variable as does the criterion.

Secondly, Dossey and Jones' (1980) conclusion from their study that "...significant predictors of routine computation skills, knowledge of mathematics concepts, and ability to apply mathematics concepts have yet to be found..." may well have been premature. Certainly Youngman's (1978) earlier report of his study of transfer effects from primary school to secondary school, comments that "...prior performance was the most powerful single predictor..." (of subsequent performance in the same area).

Dispositional variables, although statistically significant in Youngman's study, were not substantial predictors of lower-secondary school mathematics achievement. Correlations ranged from 0.32 to 0.04 for secondary dispositional variables, and from 0.27 to 0.08 for parallel upper-primary school variables. Correlations for the upper-primary school measures of attitude to school and self-concept were more consistent than parallel secondary

school measures, although marginally lower at approximately 0.26. These results are essentially the same as those reported by Guerriero (1979).

Although the dispositional variables employed as predictors in the two studies cannot be directly compared because different test inventories were used, the similarities in the two sets of results do indicate that dispositional variables, as a domain of measurement, have generally poor predictive efficiency where students' lower-secondary school mathematics achievement is the criterion.

This is certainly true of biographic variables. In Youngman's (1980) report, SEX correlated not at all with lower-secondary school mathematics achievement SMAT, while the value for AGE (0.08) failed to reach statistical significance. Guerriero (1979) reports similar results for the biographic variables used in his study. Correlations for "sex" (0.01), "family size" (-0.13), "number of siblings" (0.08), were the lowest recorded of all variables employed in the study.

The similarity of the results of the two studies strongly suggests that biographic variables are not useful predictors of students' lower-secondary school mathematics achievement.

This conclusion is strongly supported by the results of

the Taylor, Brown and Michael (1976) study of lower-secondary school algebra and geometry achievement. They used simple correlations and step-wise multiple regression analysis to determine the validity of intellectual, dispositional and biographic variables as predictors of algebra, geometry, and algebra + geometry achievement.

As with the other studies, "sex" did not correlate substantially with the criterion measures of achievement and did not enter significantly into the multiple regression equations. Correlations for the other biographic variables (various measures of parents' education and occupation) ranged from 0.01 to 0.16.

Neither the remaining biographic variables nor the dispositional variables correlated substantially with any of the criterion measures of achievement. Taylor, et al concluded from this that "...parental occupation and education, sex of student, interests, and personality characteristics have no significant relationship to mathematics..."

However, intellectual variables employed in the Taylor, et al study did substantially correlate with the criterion variables: correlations varied from 0.03 to 0.50. But, the correlations were weaker than similar correlations obtained in both the Youngman (1980) and the Dossey and Jones (1980) studies.

The results of the four studies examined so far (Taylor, et al, 1976; Guerriero, 1979; Youngman, 1980; Dossey and Jones, 1980), combined with questions which abound concerning the validity of attitude and personality inventories, cast doubts on the use of dispositional and biographic variables as predictors of lower-secondary school mathematics achievement.

Indeed, there seems little advantage in including dispositional and biographic variables in such studies. Biographic variables, almost without exception, bear little relationship to mathematics achievement at the lower-secondary school stage. Where intellectual variables have already been included in such studies, little additional information may be expected by also including dispositional variables. Studies utilising measures of the intellectual domain alone, may hold promise for substantial prediction of lower-secondary school mathematics achievement.

2.3 The Comparative Importance of Predictors

Drawn from the Intellectual Domain

Three of the studies examined so far have employed measures of the intellectual domain as predictors of lower-secondary school mathematics achievement, with varying amounts of success.

Youngman (1980) has been particularly successful in

accounting for a large portion of variance in his lower-secondary school mathematics criterion, a result which may be attributed to the nature of the intellectual variables used in his study. Youngman concludes that "...prior achievement in the same subject has the strongest effect.". His conclusion is supported by the results of the Taylor, et al (1976) and Dossey and Jones (1980) studies. These studies also used intellectual variables successfully as predictors of lower-secondary school mathematics achievement.

Taylor, et al (1976) report that step-wise multiple regression procedures resulted in intellectual variables accounting for 31% of algebra variance, 48% of geometry variance, and 47% of algebra + geometry variance. These figures compare unfavourably with the results of the Dossey and Jones (1980) study, where 52% to 60% of the variance of the measure of Grade Seven mathematics achievement was accounted for by their intellectual variables, and with the Youngman (1980) study, which accounted for 63% to 70% of the variance of the criterion measure of lower- secondary school mathematics achievement.

Youngman used upper-primary school measures of non-verbal reasoning (non-verbal I.Q.), reading comprehension, and mathematics achievement, as intellectual predictors. The highest correlation with the criterion measure of lower-secondary school mathematics achievement was obtained

with the measure of upper-primary school mathematics achievement (0.80), followed by the measure of non-verbal reasoning (0.68) and reading comprehension (0.62).

Prior performance in mathematics also proved to be the better predictor of Grade Seven mathematics achievement in the Dossey and Jones (1980) study, with correlations between the three Grade Five mathematics achievement measures and their equivalent Grade Seven measures varying from 0.67 to 0.69. Grade Five I.Q. (Otis-Lennon Mental Ability Test) correlations with the same three Grade Seven measures varied from 0.51 to 0.65.

The results of the Taylor, et al (1976) study are less clear. The I.Q. measure (Otis-Lennon Mental Ability Test) correlated 0.50 with teacher ratings of mathematics aptitude, which was identical to the correlation of the "quantitative thinking" measure with the same criterion, but higher than the correlation of the "arithmetic skills" measure with the same criterion.

Measures of mathematics achievement closely related to the three criterion measures of achievement were not used in the Taylor, et al study. The intellectual predictors were sub-tests of inventories measuring general aptitude and achievement, which probably explains the relatively low correlations of the "quantitative thinking" and "arithmetic

skills" measures with the three criterion measures, compared to the correlation of the I.Q. measure.

2.3.1 Verbal I.Q. and Non-Verbal I.Q.

The non-verbal I.Q. measure used in the Youngman (1980) study, and the verbal I.Q. measures used in the Dossey and Jones (1980) and Taylor, et al (1976) studies generally correlated well with the various criterion measures of lower-secondary school mathematics achievement: correlations varied from 0.50 to 0.68. The high correlation obtained with the Otis-Lennon Mental Ability (I.Q.) Test in Dossey and Jones' (1980) study (0.65), and with Youngman's (1980) measure of non-verbal I.Q.(0.68), means that nearly half of the variance of the criterion measure is being accounted for by the respective measure of I.Q..

The dependence of these three studies upon measures of verbal and non-verbal I.Q. raises an important question. If mathematics curricula in lower-secondary school is recognised as being relatively unsophisticated, then students' success in mathematics may not be very dependent upon verbal skills. This suggests that non-verbal I.Q. measures may generally be better predictors of mathematics achievement at this stage of schooling than verbal I.Q. measures. A future study of lower-secondary school mathematics achievement should examine the predictive efficiency of both verbal I.Q. and non-verbal

2.3.2 Reading Comprehension

Youngman's (1980) measure of reading comprehension also correlated well with the criterion measure of lower-secondary school mathematics achievement (0.62). While reading comprehension alone accounts for almost 40% of the variance of the criterion measure of lower-secondary school mathematics achievement, there is probably substantial redundancy in Youngman's use of reading comprehension and verbal I.Q. together, as predictors of the criterion. Youngman's results do not provide an answer to the question of redundancy of verbal I.Q. and reading comprehension measures. Again, this question should be examined in future studies of lower-secondary school mathematics achievement.

2.3.3 Mathematics Achievement and Mathematics Aptitude

Results of the Youngman (1980) and the Dossey and Jones (1980) studies do strongly suggest that prior mathematics achievement at the upper-primary school stage is the best predictor of mathematics achievement at the lower-secondary school stage.

However, the results of the Taylor, et al (1976) study suggest that if prior mathematics achievement is not used as a predictor of later mathematics achievement, then a measure of

"mathematics aptitude" may provide a useful predictor of later mathematics achievement.

The efficacy of such a "mathematics I.Q." measure as a useful predictor of later mathematics achievement is an important question.

Mathematics curricula at the upper-primary school stage are known to differ significantly in content and educational experience from one primary school to another. The same is true of mathematics curricula at the lower-secondary school stage. With these factors in mind, using a measure of prior mathematics achievement as a predictor of students' later success in mathematics may be inappropriate: a measure of prior mathematics achievement may be more closely related to mathematics curricula in some schools than in others and hence, the predictive validity and usefulness of measures of prior mathematics achievement may vary from school to school.

Substantial variation in the predictive validity of measures of prior mathematics achievement reduces their educational value and makes the search for a general "mathematics I.Q." measure desirable. Such a measure of mathematics aptitude may indeed be a more consistent predictor of lower-secondary school mathematics achievement across schools, than a measure of prior mathematics achievement.

Morrison (1977), in a study of achievement in secondary schools, compared the efficiency of prior mathematics achievement and mathematics aptitude measures as predictors of Grade Nine mathematics achievement. Correlations between the mathematics achievement predictor and the criterion, measured in two schools, were 0.43 and 0.65. Correlations between the Differential Aptitude Test (DAT) Numerical Ability sub-test and the criterion, in the same two schools, were higher at 0.52 and 0.69 respectively. However, Morrison's report does not state the temporal relationship of the mathematics achievement and mathematics aptitude predictors to the criterion, an omission which may confound conclusions from his study. It is interesting to note that Morrison's study was prompted by the variety of mathematics curricula at the intermediate-secondary school stage and concern about the predictive validity of mathematics achievement measures

Herman and Gallo (1973), in an earlier study of prediction in secondary schools, also examined the predictive validity of the Differential Aptitude Test. The correlation between the Grade Nine criterion measure of mathematics achievement and the DAT sub-test Numerical Ability was 0.57, a similar result to that obtained in the Morrison study.

The results of these two studies enable two tentative conclusions to be drawn. Firstly, mathematics achievement may be better predicted by mathematics aptitude measures than by

prior mathematics achievement measures. Secondly, mathematics aptitude measures are only moderately predictive of mathematics achievement, at intermediate-secondary school stage. Because of the tentative nature of conclusions about the predictive validity of mathematics aptitude measures, any future studies of prediction of mathematics achievement should include measures of prior mathematics achievement and mathematics aptitude. Furthermore, such studies may usefully compare the predictive efficiency of prior mathematics achievement and mathematics aptitude.

2.4 Importance of Using a Set of Predictors

Mathematics is a complex cognitive area, and with educational and maturational influences it becomes increasingly difficult to specify mathematics achievement in terms of simple, isolated skills. Effective prediction of mathematics achievement may lie in assembling a set of predictors and a set of criterion variables, both of which encompass the range of cognitive skills representative of this area.

Gruber and Kirkendall (1971), in commenting upon the relationship between the perceptual, perceptual-motor, and cognitive domains, said:

"The very nature of the behavioral domains under study requires that such behaviors be looked at in clusters and that any analysis undertaken be based on multiple measures of each behavioral domain."

The results of studies reviewed in this chapter support this notion. Several studies (Taylor, Brown and Michael, 1976; Dossey and Jones, 1980) utilised multiple linear regression techniques with a set of intellectual predictors. In every case, linear models based on the set of predictors accounted for substantially more variance in the criterion than was attributed to any one predictor alone.

Provided that predictors are causally related to the criterion, a combination of predictors which substantially predicts the criterion is evidence that a variety of skills contributes to the behavioral domain "mathematics ability".

2.5 Summary and Conclusions: Research Suggestions

The efficiency with which lower-secondary school mathematics achievement may be predicted depends upon the domain of measurement from which predictors are drawn:

1. Intellectual variables are useful predictors.
2. Where intellectual variables have already been included as predictors, little additional predictive information is gained by also including dispositional variables.

3. Biographic variables are not useful predictors.

In the intellectual domain, measures of previous mathematics performance may be the best predictors of lower-secondary school mathematics achievement. These measures include tests of both mathematics achievement and mathematics aptitude. However, global measures of academic achievement such as verbal and non-verbal I.Q., and measures of reading comprehension, have frequently been employed as predictors of mathematics achievement.

In considering the use of these variables as predictors of lower-secondary school mathematics achievement, a substantial gap occurs in the related literature, a gap which suggests a useful direction for research.

1. None of the studies reviewed considered the comparative efficiency of the two measures of prior mathematics performance, mathematics achievement or mathematics aptitude, as predictors of lower-secondary school mathematics achievement.

2. None of the studies which utilised measures of verbal and non-verbal I.Q. considered the

comparative efficiency of the two variables as predictors of lower-secondary school mathematics achievement.

3. In one study, both reading comprehension and verbal I.Q. were utilised as predictors but, without consideration of possible redundancy between the two measures.

Studies reviewed in this chapter have utilised a multitude of intellectual predictors covering a wide range of skills: non-verbal I.Q., reading comprehension, global measures of aptitude and achievement, and mathematics aptitude and achievement variables, are often employed as predictors. An effective approach to predicting lower-secondary school mathematics achievement may lie in combining efficient intellectual predictors to produce the best estimate of students' mathematics abilities so that school administrators, guidance counsellors and teachers can make appropriate decisions for students concerning the range of school-situational factors which are important determinants of learning success.

CHAPTER 3

RESEARCH AIMS

3.1 Introduction

There were two principle aims in the study. The first aim was to provide answers to questions concerning the relationships between certain intellectual variables and Grade Seven mathematics achievement. These variables were measures of verbal I.Q., non-verbal I.Q., reading comprehension, mathematics aptitude and mathematics achievement. The second aim of the study was to determine the combination of these variables which would produce the best estimate of students' mathematics abilities at the beginning of Grade Seven so that, school administrators, guidance counsellors and teachers can make appropriate decisions for students concerning the range of Grade Seven school-situational factors which are important determinants of learning success in mathematics.

3.2 The Relationships between Intellectual

Variables and Grade Seven Mathematics Achievement

3.2.1 Comparative Predictive Efficiency of Measures of Mathematics Aptitude and Mathematics Achievement

In Chapter 2, it was suggested that one of the reasons why prediction studies of lower-secondary school mathematics

achievement had been generally unsuccessful was the choice of inappropriate intellectual predictors.

Evidence exists (Youngman, 1978; Dossey and Jones, 1980) to suggest strongly that students' mathematics achievement at upper-primary school is the best predictor of their lower-secondary school mathematics achievement.

However, in Tasmanian schools mathematics curricula at either the upper-primary school or lower-secondary school stages are known to vary greatly in content and teaching method, factors which militate against the use of a common measure of upper-primary school mathematics achievement.

Some studies (Herman and Gallo, 1973; Taylor et al, 1976; Morrison, 1977) report the use of predictors which measure mathematics aptitude and mathematics achievement. On the basis of this evidence, it might be expected that the use of mathematics aptitude measures, as well as measures of mathematics achievement, may overcome the problem of the variety of mathematics curricula and teaching methods employed at the upper-primary school and lower-secondary school stages: the measure of mathematics aptitude would be largely independent of individual school differences.

This evidence proposes two important questions:

1. Which of the two measures of mathematics performance, mathematics achievement or mathematics aptitude, is the better predictor of Grade Seven mathematics achievement?

2. Where the measure of mathematics aptitude has already been included as a predictor, does the measure of mathematics achievement provide any additional predictive information?

3.2.2 Predictive Efficiency of Measures of Global Performance and Reading Comprehension

In addition to measures of mathematics performance (achievement and aptitude), a number of studies (Taylor et al, 1976; Dossey and Jones, 1980; Youngman, 1980) have utilised global measures (verbal I.Q. and non-verbal I.Q.) of performance. However, the relative independence of Grade Seven mathematics curricula from verbal skills suggests that non-verbal I.Q. may be a better predictor of Grade Seven Mathematics achievement than a measure of verbal I.Q..

This argument proposes two further questions:

3. Which of the two global measures of

performance, verbal I.Q. or non-verbal I.Q., is the better predictor of Grade Seven mathematics achievement?

4. Where the measure of non-verbal I.Q. has already been included as a predictor, does the measure of verbal I.Q. provide any additional predictive information?

One study (Youngman, 1980) also utilised a measure of reading comprehension as a predictor. Given the poor relationship between Grade Seven mathematics achievement and verbal skills, a measure of reading comprehension may contribute very little towards explaining variance in the criterion, once verbal I.Q. has been taken into consideration.

The argument raises the question:

5. Where verbal I.Q. has already been included as a predictor of Grade Seven mathematics achievement, does the measure of reading comprehension provide any additional predictive information?

3.2.3 Comparative Predictive Efficiency of Measures
of Prior Mathematics Performance, Global Performance
and Reading Comprehension

In considering the evidence and implications concerning the comparative predictive efficiency of measures of prior mathematics performance and global performance measures, two further questions arise:

6. Are the two measures of prior mathematics performance, mathematics aptitude and mathematics achievement, better predictors of Grade Seven mathematics achievement than the two global measures of performance, verbal I.Q. and non-verbal I.Q.?

7. Where the two measures of prior mathematics performance have already been included as predictors of Grade Seven mathematics achievement, do the two measures of global performance, taken together, provide any additional predictive information?

Reading comprehension may have little relationship with Grade Seven mathematics Achievement, particularly if global performance and prior mathematics performance measures are considered first. This raises the question:

8. Where measures of prior mathematics performance and global performance have already been included as predictors of Grade Seven mathematics achievement, does the measure of reading comprehension provide any additional predictive information?

3.3 Predicting Mathematics Ability

Correct decisions on the part of secondary school administrators, guidance counsellors and teachers concerning school-situational factors depend upon adequate performance/background data being available for students.

At the present time, decisions concerning Grade Seven students are based upon very limited background information provided by feeder primary schools, and the results of tests measuring verbal I.Q., non-verbal I.Q. and reading comprehension. Despite the lack of knowledge of the relationship between mathematics ability and a student's performance/background data, school administrators, guidance counsellors and teachers have in the past made decisions for Grade Seven students concerning ability groups, teacher, class size, and remedial teaching.

The extent to which intellectual variables are related

to students' mathematics abilities at lower-secondary school is at present unknown. Global performance measures (verbal and non-verbal I.Q.) and a measure of reading comprehension provide little direct information concerning students' strengths and weaknesses in mathematics during upper-primary school, and provide little predictive information for the same students concerning their strengths and weaknesses in mathematics at the start of the Grade Seven year. While measures of upper-primary school mathematics performance (aptitude and achievement) are known to provide more information about students, a combination of relevant intellectual variables may more accurately describe the set of behaviors known as mathematics ability.

Such a combination of variables may include measures of prior mathematics performance, global performance, and reading comprehension, and would more exactly model students' mathematics abilities at the start of the Grade Seven year than any one variable considered alone. This argument raises the question:

9. Can an economic and educationally significant multivariate linear model be determined, with Grade Seven mathematics achievement as the criterion, and statistically and conceptually significant intellectual variables as predictors? The "predicted"

criterion scores would then be the best estimate of students' mathematics abilities at the beginning of the Grade Seven year.

CHAPTER 4

DESIGN AND PROCEDURES

4.1 Introduction

This chapter presents an overview of research design employed in the study; description of the population and research samples; a review of the research instruments used to gather empirical data and definitions of metric variables derived from these instruments; and procedures employed with test instruments and data collection.

4.2 An Overview of Research Design in the Study

The two aims of the study were: (1) to examine the relationships between Grade Seven mathematics achievement and a range of intellectual variables; (2) to determine the combination of intellectual variables which best predicts Grade Seven mathematics achievement.

Subjects for the study were students enrolled in Grade Seven at New Town High School during 1982 and 1983.

This school was selected for several reasons: the writer is a teacher and school administrator at the school, with

first-hand experience of the difficulties of, (a) assessing the strengths and weaknesses in beginning students' mathematics backgrounds, (b) making decisions for beginning students concerning ability groups, remedial teachers, class group teachers and class sizes; the school is situated in a relatively homogeneous socio-economic area, which is predominantly middle-class; the school, while regarded as essentially traditional in its philosophy, is nevertheless fairly typical of most secondary schools in Tasmania and hence, results from the study should have acceptable external validity.

With the multivariate nature of mathematics achievement well established, the determination the relationships between Grade Seven mathematics achievement and intellectual predictors required a set of test instruments which, as far as possible, would measure the whole range of mathematics knowledge together with those cognitive skills which assist the acquisition and processing of such knowledge. Six test instruments were employed in the study and the reasons for their selection are described in section 4.4.

Mathematics achievement at the end of Grade Seven was measured with the instrument usually employed in the school for this purpose, the CRITERION MATHEMATICS ACHIEVEMENT TESTS. The range of students' mathematics knowledge at the commencement of the Grade Seven year was measured with the ACER

CLASS ACHIEVEMENT TEST IN MATHEMATICS (CATIM 6/7) (A.C.E.R., 1976), while the extent of students' understanding of basic mathematical operations was measured with the ACER MATHEMATICS PROFILE SERIES OPERATIONS TEST (A.C.E.R., 1977). The assessment of students' wider cognitive skills was also important. A measure of verbal I.Q., the ACER TEST OF LEARNING ABILITY-TOLA 6 (A.C.E.R., 1976), a measure of non-verbal I.Q., the ACER STANDARD PROGRESSIVE MATRICES TEST (adapted by A.C.E.R., and based on Raven's 1938 Progressive Matrices), and a measure of reading comprehension, the GAP READING COMPREHENSION TEST THIRD EDITION (Heinemann, 1976) were selected for this purpose.

Analysis techniques employed with empirical data must answer the research questions. Basic descriptive statistics and zero-order correlations were appropriate techniques for data analysis concerned with questions of comparative predictive efficiency of intellectual variables. However, questions concerned with prediction of the criterion by two or more predictors were best answered through use of multivariate analysis techniques so that the complex relationships between the criterion and predictors could be closely modelled.

4.3 Population and Samples

The samples for the study were drawn from the population of students enrolled in Grade Seven, at New Town High School,

during 1982 and 1983. A total of 391 Grade Seven students were involved in at least one aspect of data collection for the study. Of these, 193 students constituted the 1982 enrolment, while the remaining 198 students constituted the 1983 enrolment.

Attrition during the study, due to lack of complete data for cases, reduced the size of the 1982 sample to 158 subjects (35 missing cases), the 1983 sample to 155 subjects (43 missing cases), and the whole data sample (1982 and 1983) to 313 subjects.

Factors which caused attrition amongst students in the 1982 and 1983 Grade Seven year groups were: transfer from New Town High School to another school during the year; transfer from another school to New Town High School during the year; normal absenteeism from the class during a test relevant to the study. However, the most important factor which resulted in attrition amongst both 1982 and 1983 students was lack of data, from some smaller feeder primary schools, concerning either verbal I.Q. or non-verbal I.Q.. This factor alone was responsible for 35 missing cases.

The results of the analysis of bias in attrition from the 1982 and 1983 Grade Seven groups will be discussed later in this report but, insofar as drop-outs from the two groups were due to the same reasons, any loss of subjects was essentially

random: attrition will bias sample representiveness of, rather than comparisons between, the two year groups.

4.4 Description of Instruments and Intellectual

Variables in the Study

The study utilised one dependent variable and five independent variables in the analysis of Grade Seven mathematics achievement. All variables were derived from test instruments.

4.4.1 Choice of Instruments and Intellectual Variables

Three factors were important in determining the choice of test instruments from which the criterion and the five intellectual predictors were derived.

Firstly, mathematics is a complex cognitive area. By the end of primary school, with the influences of maturational and educational factors, mathematics achievement has become increasingly difficult to specify in terms of simple, isolated skills. Test instruments are required which will measure not only the range of mathematics knowledge possessed by students but, also the range of cognitive skills which are necessary for the acquisition and processing the mathematics knowledge.

Research into prediction of mathematics achievement has

shown clearly that global measures of academic achievement, such as verbal I.Q. and non-verbal I.Q., and measures of reading comprehension, are educationally significant predictors of lower-secondary mathematics achievement. Nevertheless, while it is believed that these variables will be important predictors of Grade Seven mathematics achievement, measures of prior (upper-primary school) mathematics achievement and mathematics aptitude may well be the best predictors of such achievement, and hence, effective prediction of Grade Seven mathematics achievement would require the employment of test instruments which would provide measures for each of the five predictors: verbal I.Q., non-verbal I.Q., reading comprehension, mathematics achievement, and mathematics aptitude.

Secondly, the choice of test instruments used to gather data for the study was determined, to a large degree, by their widespread use and acceptance amongst the educational community. The five test instruments from which predictors were derived are well known to teachers and educational psychologists, and are accepted as being valid and useful tests.

Both the ACER TEST OF LEARNING ABILITY-TOLA 6 and the ACER STANDARD PROGRESSIVE MATRICES have been widely used by secondary school guidance counsellors for I.Q. testing of primary school students during the latter part of Grade Six.

These two global measures of academic achievement have recently been joined by the GAP READING COMPREHENSION TEST THIRD EDITION which, it is hoped, will identify students who require remedial assistance with reading during the Grade Seven year.

The ACER CLASS ACHIEVEMENT TEST IN MATHEMATICS (CATIM 6/7) and the ACER MATHEMATICS PROFILE SERIES OPERATIONS TEST have been used by guidance counsellors and teachers as sources of additional data concerning the mathematics skills and knowledge of students who have been identified by the I.Q. tests as exceptional. While the ACER CLASS ACHIEVEMENT TEST IN MATHEMATICS (CATIM 6/7) is highly regarded as a useful survey of primary school mathematics achievement, the ACER MATHEMATICS PROFILE SERIES OPERATIONS TEST is often used as a measure of mathematics "learning ability", or the rate at which a student can learn mathematics in Grade Seven and, as such, it is an important pointer to under-achievers.

A sixth test instrument, the CRITERION MATHEMATICS ACHIEVEMENT TESTS, was developed as part of the established Grade Seven testing programme carried out during 1982 and 1983.

Thirdly, the five test instruments which yielded predictors used in the study, are freely available to schools through-out the country. With the exception of the CRITERION MATHEMATICS ACHIEVEMENT TESTS, all tests are published, or

distributed, by the Australian Council for Educational Research (A.C.E.R.), a national independent organization involved with test development, provision of testing services, and evaluation and development of educational materials.

4.4.2 Description and Validation of Instruments and Definitions of Intellectual Variables

Summary descriptions of six test instruments used in the study are provided in this section. Two measures of mathematics achievement, together with a measure of mathematics aptitude, are defined directly from scores on three test instruments. Measures of verbal I.Q., non-verbal I.Q. and reading comprehension are provided by the remaining three test instruments.

Complete copies of the CRITERION MATHEMATICS ACHIEVEMENT TESTS, the ACER CLASS ACHIEVEMENT TEST IN MATHEMATICS (CATIM 6/7), and the ACER MATHEMATICS PROFILE SERIES OPERATIONS TEST may be found in APPENDIX I. Copies of the ACER TEST OF LEARNING ABILITY-TOLA 6, the ACER STANDARD PROGRESSIVE MATRICES, and the GAP READING COMPREHENSION TEST THIRD EDITION are restricted to educational psychologists within guidance branches of education departments, or to other agencies requiring tests not available on the open market. Full descriptions of these tests may be found in the users handbooks, listed in Bibliography.

CRITERION MATHEMATICS ACHIEVEMENT TESTS

This instrument was designed to survey the range of mathematics skills of Grade Seven students attending New Town High School at the end of the Grade Seven year. Two versions of this test were used, the first with the 1982 sample, and the second with the 1983 sample.

The format and content of the tests were determined by the syllabus requirements of The Schools Board of Tasmania for Mathematics, and School policy in regard to testing of students. While other, more sophisticated measures of mathematical achievement might have been used, nearly all utilised multiple-choice items, and none satisfactorily encompassed the range of mathematical knowledge which formed the mathematics syllabus for Grade Seven at the school.

This achievement test is the final test of five which monitored the development of students' mathematics skills during their Grade Seven year. Together with similar tests in other areas of the school's curricula, the test was used to evaluate students' progress, and provide information on such progress to parents, guidance counsellors and school administrators. The test had application in determining ability groupings for Grade Eight and the allocation of students for remedial teaching.

The test, of 90 minutes duration, consisted of items drawn from the five major skill areas of Grade Seven Mathematics: numbers and operations, social mathematics, spatial concepts and geometry, measurement, and algebra of real numbers.

Items in the test were broadly grouped into two categories. The first category consisted of 50 items which tested basic facts and operations in number, money, measurement, geometry, and algebra. These items were responded to with a unique solution which did not require extended working. Items in the second category, drawn from the five skill areas, required extended working for solution. The item solution, together with its working, was required for a full score to be awarded. For the study, scores on test items were totalled, and a total score (maximum of 100) computed for each student.

Measures of the dependent variable CMAT, representing Grade Seven mathematics achievement, were students total scores in the test.

ACER CLASS ACHIEVEMENT TEST IN MATHEMATICS (CATIM 6/7)

The ACER Class Achievement Test in Mathematics was designed to survey the mathematics skills of students in Grades Six and Seven, and as such, it is an appropriate measure of students' upper-primary school mathematics achievement.

The test, based upon the earlier ACER Mathematics Tests (AM Series), consists of 45 multiple-choice items drawn from 11 skill areas: counting and place value, whole numbers, money, common fractions, decimal fractions, spatial relations, length, area, volume and capacity, mass and weight, and time. There are sufficient items in each skill area to broadly assess the progress of each student in that area.

In addition to skill area, each item in the test has also been classified into four relatively distinct areas, which describe in general the nature of the thinking process required to correctly respond to the item. These areas are knowledge, computation, application, and understanding.

In the present study, students attempted all 45 items in the test, with a raw score (maximum of 45) computed for each student. The variable MACH, representing upper-primary school mathematics achievement, was defined as students' raw scores in the test.

ACER MATHEMATICS PROFILE SERIES OPERATIONS TEST

This test is one of four tests which together form the Mathematics Profile Series. The series is designed to provide a flexible system for monitoring students' mathematical development from mid-primary to late-secondary school. The purpose of the test is to assess students' understanding of

familiar operations in the real number field, and as such, it has been possible to broadly interpret test performance in terms of the Piagetian developmental stages (OPERATIONS TEST Teachers Handbook, p16). Such an interpretation may provide an estimate of students' mathematical aptitudes or, capacity to acquire new mathematics knowledge.

The Operations Test consists of sixty multiple-choice items arranged into three subsets each of twenty items. Each subset is characterized by the "elements" being operated upon, with the elements being small numbers (less than 20), large numbers (20 to 99), and pronumerals. Corresponding to each subset of twenty items, twenty different item "structures" are distinguished. These involve different operations and combinations of operations which include the commutative, associative, distributive, identity and inverse properties. The twenty different structures are repeated for parallel items in each subset, and the items within each subset are arranged in order of increasing complexity based on the mean difficulty for a given structure across the three elements.

The items used in the Operations Test are based upon those developed by Collis (1975) in his research into students' levels of mathematical development. Collis found that the complexity of the items for students depended upon the interaction between the structure of the operations and the nature of the elements being operated upon. While the main

factor was shown to be the structure of the operations, the increasingly abstract nature of the elements had a small but consistent effect.

In the present study, it was deemed inappropriate to use items involving pronumeral elements because, at this stage of schooling, students had not been exposed to operations with pronumerals. Instead, 40 items, comprising the first two subsets of items, were used. Students' scores for the test provided measures for the variable representing students' mathematics aptitude, MAPT.

ACER STANDARD PROGRESSIVE MATRICES

This test of general ability, based on Raven's (1938) Progressive Matrices, is designed to assess a subject's capacity at the time of the test to apprehend meaningless figures presented for the subject's observation, see the relations between them, conceive the nature of the figure completing each system of relations presented, and by so doing, demonstrate a systematic method of reasoning.

The ACER STANDARD PROGRESSIVE MATRICES contains five sections (A, B, C, D, E), each of twelve items, printed in a booklet for use with a separate answer sheet. Each of the sixty items is a design or "matrix" from which a part has been removed. The student is required to examine the design and decide from a number of pieces given below it, which is the

correct one to complete the design. In each of the five sets the first problem is as nearly as possible self-evident. The following problems in the set become progressively more difficult. Standard training in the method of working is provided in the order of the tests.

Comparison of the ACER Standard Progressive Matrices with other commonly used non-verbal I.Q. tests, using factor analysis techniques, has shown that 64% to 72% of the variance of Standard Progressive Matrices scores can be attributed to a general ability factor, while approximately 12% of variance can be attributed to a spatial visualisation factor. The loadings of Standard Progressive Matrices scores on verbal, number, and speed factors are either weakly negative or not significant. Test-retest reliabilities varied from 0.75 to 0.79, while the split-half reliability was 0.91. Thus the ACER Standard Progressive Matrices Test has the characteristics of non-verbal, general ability test with a small spatial component. For the purposes of the study, I.Q. range scores were used as measures for the variable NVIQ.

ACER TEST OF LEARNING ABILITY - TOLA 6

The TOLA 6 has been designed to assess the general intellectual ability of English-speaking students who have completed six years of primary schooling. The purpose of the test is to measure broad language and reasoning abilities, which are important for academic success in secondary school.

A.C.E.R., the publishers of TOLA 6, point out to test users that the test does not predict academic achievement, but does provide a measure of the general ability or intelligence component required for such achievement.

The TOLA 6 provides a single score measure of general ability which is derived from scores on three multiple-choice subtests covering verbal comprehension, mathematical reasoning, and verbal analysis respectively.

Reliability coefficients for the TOLA 6, using the Kuder-Richardson formula 20, are satisfactory: the vocabulary subset varied from 0.89 to 0.91; the mathematical reasoning subset varied from 0.72 to 0.73; the verbal analysis subset varied from 0.81 to 0.83. Correlations between the TOLA 6 and three other well accepted measures of general ability (ACER Intermediate Test E, SRA Primary Mental Abilities, and the OTIS AB) ranged from 0.75 to 0.83. A.C.E.R. concluded that the TOLA 6 is a useful measure of general intellectual ability.

Although the TOLA 6 appears to be separated into three subtests measuring separate abilities, the subtests exist only for ease of administration of different item types. The test yielded I.Q. range scores for measures of verbal I.Q. for the variable VIQ.

GAP READING COMPREHENSION TEST THIRD EDITION

Reading comprehension itself is often regarded as an equivocal concept. Researchers have isolated at least nine factors in the analysis of reading comprehension, and it is clear that a student's score on a test of reading comprehension depends upon the questions being asked as well as the material upon which the questions are based.

In the GAP test, a modified Cloze technique is used in a standardised instrument for measuring reading comprehension. Cloze-type tests, widely recognized as valid measures of comprehension, have been found to be decidedly more reliable than conventional multiple-choice reading comprehension tests.

The original version of the GAP test was revised in 1976 because experience had shown that some items had become inappropriate. The new version of the has shown marginally better discrimination than the original version. Reliabilities of the revised GAP test, using the half-split method on samples of children at three different age groups, vary from 0.90 to 0.94. The test is recommended for students aged from 7.3 to 12.6 years, and is not recommended beyond primary school. GAP test scores are usually presented as reading age equivalent scores but, in this study, the raw score was used instead, to provide measures for the variable RCOM.

4.5 Procedures

The study was concerned with analysis of scores derived from a test battery and archival information. A total of 391 Grade Seven students, during 1982 and 1983, were involved in at least one aspect of data collection.

Three tests relevant to the study were administered to Grade Seven students in their beginning year. During the final week in February, class group teachers administered two tests to their own classes: students initially completed the ACER MATHEMATICS PROFILE SERIES OPERATIONS TEST, followed by the ACER CLASS ACHIEVEMENT TEST IN MATHEMATICS (CATIM 6/7) the following day. During the final week in November, all students were assembled into one group and were administered the CRITERION MATHEMATICS ACHIEVEMENT TESTS, supervised by class group teachers.

Unlike the test conducted during the final week in November, the two tests conducted during the final week in February were not completed by all class groups at the same time, but test conditions were essentially identical for all class groups: tests were held during the early part of the morning; students were provided with the same test preamble and test materials; similar classroom conditions prevailed across class groups.

Testing was undertaken during the final week in February and during the final week in November for two reasons:

1. The first week in March marks the start of formal teaching in Grade Seven. Hence, tests conducted during the final week in February would not be confounded by "new" mathematics knowledge.

2. The final week in November coincides with the School's testing programme for all aspects of the Grade Seven curriculum: it was not possible to conduct tests at a later date.

Grade Seven class group teachers were all experienced teachers, well-qualified to administer group tests to Grade Seven students. In the week prior to testing, a group training session was conducted with Grade Seven class group teachers: they were instructed on the nature of the tests, procedures for administration, and the rationale of the testing programme for the year.

Scoring of students' responses to the ACER Operations Test and the ACER CATIM 6/7 was done by the writer, according to instructions accompanying these tests. However, scores for the Criterion Mathematics Achievement Tests were determined by Grade Seven class group teachers. To minimize rating errors amongst teachers, a comprehensive scoring scheme was prepared,

with each teacher scoring the same set of test items across all students.

Students did not undertake I.Q. and reading comprehension tests during the Grade Seven year, but were administered these tests by the secondary school guidance counsellor during the latter part of their Grade Six year; the administration and scoring of these three tests were the sole responsibility of the guidance counsellor. Students' scores gained on these three tests, together with their birthdates, were obtained from school records.

4.6 Summary

The aims of the present research were to investigate the relationships between Grade Seven mathematics achievement and a range of intellectual variables; and to determine the combination of these variables which best predicted individual Grade Seven mathematics Achievement, such a combination may be regarded as the best estimate of students' mathematics abilities at the beginning of Grade Seven.

Intellectual variables were defined from instruments already widely accepted and used in primary and secondary schools.

The present study utilised one dependent variable and

five independent variables in the investigation of Grade Seven mathematics achievement. The variables were:

Dependent Variable (criterion)

Grade Seven Mathematics Achievement - CMAT

Independent Variables

Upper-primary School Mathematics Achievement - MACH
Mathematics Aptitude - MAPT
Non-verbal I.Q. - NVIQ
Verbal I.Q. - VIQ
Reading Comprehension - RCOM

Analysis of empirical data utilised descriptive statistics, zero-order correlations, and multiple linear regression techniques.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Introduction

The results of the investigation of the relationships between five intellectual variables and Grade Seven Mathematics Achievement are presented in this chapter. Summary tables and figures reflect the findings of statistical analyses of empirical data, and significant statistics are examined and discussed.

Several statistical treatments were used to develop the analysis of empirical data necessary to evaluate the research questions. For the five intellectual variables, which the literature review indicated a high degree of relationship with Grade Seven Mathematics Achievement, basic descriptive statistics, zero-order (Pearson product-moment) correlation coefficients and multiple linear regression techniques provided a broad base upon which the actions and interactions of the variables might be examined, and the research questions answered.

Data processing of the statistical techniques was performed on the Burroughs B6800 mainframe computer at the Computing Centre of the University of Tasmania. The computer

programs employed for data processing were drawn from SPSS - Statistical Package for the Social Sciences. The programs used were, CONDESCRIPTIVE and FREQUENCIES for descriptive statistics, PEARSON CORR for zero-order correlation coefficients, and REGRESSION for multiple linear regression. Appropriate tests of significance were employed to evaluate statistics determined by the data analysis.

5.2 Student Performance on Test Instruments

The usual descriptive statistics were determined for the dependent variable CMAT, and each of the five independent variables MACH, MAPT, NVIQ, VIQ, and RCOM; basic descriptive statistics for CMAT for the three samples are presented in TABLE 5.1 (p. 73), while basic descriptive statistics for the five independent variables are presented in TABLE 5.2 (p. 74). Frequency histograms of whole data sample scores for each of the six variables are presented in APPENDICES II.

5.2.1 Samples and Attrition

A total of 391 students, being the Grade Seven enrolments of 1982 and 1983, were involved in at least one aspect of empirical data collection. From TABLES 5.1 and 5.2, it may be seen that a small number (less than 10% of the enrolment) of students were registered as missing cases in the data for each instrument. These students were either absent

TABLE 5.1

Basic Descriptive Statistics for Dependent Variable CMAT
for 1982, 1983, and Whole Data Samples

SAMPLE	MEAN	STD DEV	N	MISSING CASES
1982	48.54	19.43	183	10
1983	49.03	20.88	179	19
Whole Data	48.79	20.14	362	29

TABLE 5.2Basic Descriptive Statistics for Independent Variables(All Cases)

VARIABLE	MEAN	STD DEV	N	MISSING CASES
MACH	31.64	6.99	365	26
MAPT	26.17	6.62	356	35
NVIQ	102.88	11.79	356	35
VIQ	100.71	14.28	372	19
RCOM	30.52	6.17	367	24

absent from secondary school during one of the test-sessions or, were not tested by the guidance counsellor during visits to feeder primary schools. Generally higher absenteeism was recorded with tests completed at secondary school (26 - 35 missing cases) than was recorded in primary school archival data (19 - 35 missing cases). From random checking of causes of absenteeism during secondary school test-sessions, it was concluded that absenteeism from tests was due to normal causes, and hence, drop-outs from the study will bias sample representativeness of, rather comparisons between, the three samples. Hence, it was unlikely that results were prejudiced.

The reasons for the absence of some archival data for students was less subject to inspection. Certainly normal causes were suspected in most of the missing cases, but some smaller feeder primary schools were known to have resisted the testing of their students: the effect was that students who were absent during the guidance counsellor's timetabled visit to the primary school were not subsequently tested. This was not the case in most feeder primary schools, and accounts for fewer missing cases with archival data than with test-session data. Again, it was unlikely that results were prejudiced.

Comparison of sample means (TABLE 5.1) for the dependent variable CMAT, using the t-test for independent means, showed that there was no difference on this performance measure

between the 1982 and 1983 samples:

$$t = 0.23 < t_{0.95, 360} = 1.96$$

It therefore appeared reasonable to combine these samples to produce the larger whole data sample, which provided the data base for much of the study.

305 students were present for all aspects of data collection, and this group became the whole data sample from which the relationships between Grade Seven Mathematics Achievement and the intellectual variables were determined.

5.2.2 Grade Seven Mathematics Achievement (CMAT)

Two important conclusions may be drawn from values determined for descriptive statistics on the Criterion Mathematics Achievement Tests (CMAT).

Firstly, a normal distribution of scores in the criterion is an important assumption underlying multiple linear regression analysis - which was employed with this criterion and described later in this report. The distribution of scores in the Criterion CMAT differs little from a normal distribution: the values for kurtosis and skewness (-0.53, 0.22) show that the distribution is marginally flattened and marginally skewed to the left; values for the mean, mode and median (48.79, 45.00, 47.83) are nearly coincident. Such a

distribution does not substantially violate the assumption of normality critical in regression analysis.

Secondly, the discrimination of the Criterion Mathematics Achievement Tests appears to be good. The tests were designed to produce a mean of approximately 50, and substantially spread the scores of students, which was achieved. While no measures of validity were determined, this does not mean that the test has doubtful validity. It is always worth while remembering that the effectiveness of a particular test instrument rests upon logical and educational grounds, and not on unthinking indices of test validity. It was upon such assumptions that the Criterion Mathematics Achievement Tests were designed. While these tests were unique to the setting of this study, many other schools are known to test mathematics achievement in much the same way, particularly those schools using mathematics syllabuses set down by the Schools Board of Tasmania. It is reasonable to conclude that the instrument from which the criterion was derived formed a valid measure of students' mathematics achievement at the end of Grade Seven.

5.2.3 Upper-Primary School Mathematics Achievement (MACH)

Values for kurtosis and skewness (0.35, -0.62) indicate that the distribution of scores on the MACH measure is marginally peaked and skewed to the right. The high mean

score and low standard deviation (TABLE 1, p. 74) reflect the generally high scores obtained by most students on this test. While the ACER CLASS ACHIEVEMENT TEST IN MATHEMATICS (CATIM 6/7) is widely accepted by teachers and educational psychologists, the results show that a more difficult test of mathematics achievement may have been more appropriate, in terms of difficulty, for an assessment of the range of mathematics knowledge possessed by students in late-primary/lower-secondary school.

Such an assessment might be provided by the PROFILE OF MATHEMATICAL SKILLS (France, N.), introduced and adapted for Australia by ACER in 1981. This test, which became available to schools after commencement of this study, is not widely used in lower-secondary school at the present time but, as the LEVEL 2 version is suitable for use with Grade Six to Grade Eight students, it has the potential to discriminate better between the more able Grade Seven students than the ACER CATIM 6/7.

5.2.4 Mathematics Aptitude (MAPT)

The distribution of scores on the ACER OPERATIONS TEST differs little from a normal distribution: values for kurtosis and skewness (-0.14, -0.30) indicate a distribution which is only marginally flattened and skewed to the right, while the mean (26.17), mode (24.00) and median (26.11) are nearly coincident. With a standard deviation of 6.62, the

descriptive statistics indicate that, in terms of difficulty, the ACER Operations Test adequately discriminated between students throughout the range of scores.

Use of norm-referenced data supplied with the ACER OPERATION TEST Teachers Handbook (p. 34) has enabled some conclusions to be drawn concerning the whole data sample used in the study.

Firstly, the mean score of 26.17, obtained on the first forty items in the test, corresponds to a score, on the Rasch measurement scale, of 53 brytes. A.C.E.R. have related the OPERATIONS TEST Rasch measurement scale to the Piagetian cognitive developmental stages (Teachers Handbook, p. 17): the score of 53 brytes places the study sample towards the top of the "concrete generalization" or "early formal" stage, a result which is surprising given the stage of schooling and age of students in the sample.

Secondly, age/school year characteristics have also been related to the Rasch measurement scale (Teachers Handbook, p. 21): the score of 53 brytes corresponds to an age of 14 years and the ninth year of schooling. Since the mean age of students in the sample is only 12.5 years, there must be some doubt as to the validity of the A.C.E.R age/school year characteristics.

5.2.5 Reading Comprehension (RCOM)

The distribution of scores on the GAP READING COMPREHENSION TEST is markedly non-normal: values for kurtosis and skewness (0.94, -1.07) indicate that the distribution is substantially peaked and skewed to the right; values for mean (30.52), mode (37.00) and median (31.98) are far from coincident. The GAP test failed to adequately discriminate between the more able readers: most students obtained high scores on the test, while many obtained full scores.

While the GAP READING COMPREHENSION TEST THIRD EDITION is suitable for students with a reading age range 7.3 - 12.6yrs., many of those students who participated in the study have registered at, or close to, the upper limit of the reading age range.

Future studies utilising a reading comprehension test with students in upper-primary school or lower-secondary school should choose a more difficult instrument than the ACER GAP test. Such an instrument should retain the lower- and middle-range reading age characteristics of the GAP test while providing an upper-range reading age which would discriminate between the more competent Grade Six readers.

Certainly the ACER GAPADOL READING COMPREHENSION TEST, which provides a reading age range from 7.5 - 16.11yrs., would

better measure the whole range of reading skills found in upper-primary/lower-secondary school.

5.2.6 The I.Q. Tests (NVIQ and VIQ)

Values for kurtosis and skewness (-0.65, 0.24) indicate that the distribution of verbal I.Q. scores was flattened and slightly skewed to the left, while for non-verbal I.Q., similar statistics (-0.24, -0.19) indicate that the distribution was only slightly flattened and slightly skewed to the right: frequency distributions of scores for both measures were essentially normal distributions.

Reliable normative data for the ACER TOLA 6 and STANDARD PROGRESSIVE MATRICES I.Q. tests were not available for Tasmania, nor were the school's previous Grade Seven I.Q. tests results available from archives. Consequently, it was not possible to compare students' performances in the I.Q. tests with a larger, more representative sample, or with the school's performance in previous years. However, on the I.Q. tests there was no reason to believe that the 1982 and 1983 enrolments were markedly dissimilar to previous Grade Seven enrolments.

5.3 Predictive Efficiency of Intellectual Variables

Answers to research questions concerned with the

predictive efficiency of intellectual variables were determined from zero-order Pearson product-moment correlation coefficients calculated for these variables, and multiple linear regression analyses.

The first stage in the analysis was the examination of the correlation matrix for the intellectual variables and Criterion. The significance of intercorrelations was determined; substantial differences between particular correlations were examined to provide answers to research questions concerned with comparative predictive efficiency. Multiple linear regression techniques were utilised to provide answers to other research questions, concerned with contribution of particular intellectual variables to various prediction models.

While research questions were stated in Chapter 3, it is necessary to provide a framework for the issues under investigation: a statement of formal hypotheses precedes the description of the analysis techniques employed to determine the predictive efficiency of intellectual variables.

5.3.1 Statement of Formal Hypotheses

1. There will be no significant correlation between Grade Seven Mathematics Achievement (CMAT) and each the following five intellectual variables:

- (a) Upper-Primary School Mathematics Achievement (MACH);
- (b) Mathematics Aptitude (MAPT);
- (c) Non-verbal I.Q. (NVIQ);
- (d) Verbal I.Q. (VIQ);
- (e) Reading Comprehension (RCOM).

If HYPOTHESIS 1 is rejected, it is valid to test HYPOTHESES 2 and 3.

2. There will be no significant difference with respect to efficiency in predicting Grade Seven Mathematics Achievement (CMAT) for the following pairs of intellectual variables:

- (a) Upper-Primary School Mathematics Achievement (MACH) and Mathematics Aptitude (MAPT);
- (b) Verbal I.Q. (VIQ) and Non-verbal I.Q. (NVIQ);
- (c) Verbal I.Q. (VIQ) and Reading Comprehension (RCOM);
- (d) measures of prior mathematics performance (MAPT + MACH) and measures of global performance (NVIQ + VIQ).

3. There will be no significant increase in efficiency in predicting Grade Seven Mathematics Achievement (CMAT) for:

- (a) Upper-Primary School Mathematics Achievement (MACH) beyond that which may be attributed to

Mathematics Aptitude (MAPT);

- (b) Verbal I.Q. (VIQ) beyond that which may be attributed to Non-verbal I.Q. (NVIQ);
- (c) global measures of performance (VIQ, NVIQ) beyond that which may be attributed to measures of prior mathematics performance (MACH, MAPT);
- (d) Reading Comprehension (RCOM) beyond that which may be attributed to Verbal I.Q. (VIQ);
- (e) Reading Comprehension (RCOM) beyond that which may be attributed to measures of prior mathematics performance (MACH, MAPT) and global performance (NVIQ, VIQ), taken together.

5.3.2 Description of Analysis Techniques

Correlations for all pairs of variables were computed. In section 5.2, it was demonstrated that frequency distributions for variables were approximately normal distributions, thus satisfying one of the assumptions underlying regression. The assumption of homogeneity of variance is regarded as important by some writers but, Ahlgreen and Walberg (1970, p. 34), in a comparative review of regression theory, contend that regression is robust with respect to violations of assumptions of normality and homogeneity. However, scatterplots were used to provide a visual check of the relationships between correlation pairs.

The test statistic "t", which has the usual t-distribution, was utilised to investigate the significance of correlations determined for the criterion and intellectual variables. The smallest, significant correlation was found by calculating the critical t-value, from which the critical value for "r" was determined.

The test of significance employed with the t-statistic was important. In Chapter 2, from the literature review, it was concluded that correlations between the criterion and each of the intellectual variables would be substantial and positive. Hence, a directional or one-tailed test of significance, with a 0.95 confidence interval, was appropriate. This maximised the probability of not making a type-II error, while a 0.95 confidence interval would ensure that the probability of making a type-I error was also low.

Once the significance of correlations had been established, it was necessary to determine whether pairs of correlations were significantly different. The z-test for dependent samples (Glass and Stanley, 1970, p. 313) was utilised for this purpose: z-ratios were determined for each pair and compared with the critical z-value of 1.96 (0.95 confidence interval).

However, the analysis of simple correlations between the variables cannot adequately describe their effects on the

Criterion. From the review of related literature, it was clear that the intellectual variables were likely to be highly inter-related thus confounding any interpretation of their separate effects.

A partial escape from the ambiguities afforded by such interpretation is provided by stepwise multiple regression analysis. While this technique is usually well treated in any statistics text concerned with multivariate analysis, several important notions will be reviewed.

Firstly, the relationship between the criterion and a set of predictors is expressed by a linear model equation, characterised by the multiple correlation coefficient R . The proportion of variance in the criterion accounted for by the predictors taken together is equal to R -squared.

Secondly, the interpretation of how much each predictor contributes to variance in the criterion becomes more difficult with every additional predictor. The interpretation of the separate effects of multiple predictors is aided by adopting a stepwise inclusion approach.

In the investigation of the effects of intellectual variables on the Criterion using stepwise regression, a series of regression models was tried, each model including a different set of predictors. For each step in the regression,

there was an overall significance test for R , and also a significance test for improvement in R -squared achieved by that step.

Thirdly, multiple linear regression assumes a linear relationship between the criterion and the predictors, but is robust with respect to violations of normality and homogeneity of variance assumptions. However, significance tests associated with multiple linear regression are based upon certain assumptions concerning residual scores (the difference between the predicted value of the criterion and its actual value). More specifically, it is assumed that the residuals are (1) independent, (2) have a mean of zero, and (3) have the same variance throughout the range of criterion values. Substantial departures from these assumptions can usually be determined by direct examination of residuals, and since such an examination involves a search for visible patterns, it was accomplished most readily from the scatterplot of residuals.

5.3.3 Analysis of Correlations

From TABLE 5.3 (p. 88) it may be seen that all intercorrelations were positive and substantial. The critical value for "t", for the whole data sample of 305 cases and a directional test of significance with a confidence interval of 0.95, was determined to be 1.65. From the critical t-value, the critical r-value was determined to be 0.09.

TABLE 5.3Zero-order Correlations for Intellectual Variables(All Cases)

	CMAT	NVIQ	VIQ	RCOM	MAPT	MACH
CMAT	1.00	0.57	0.65	0.55	0.75	0.70
NVIQ	0.57	1.00	0.58	0.42	0.52	0.57
VIQ	0.65	0.58	1.00	0.72	0.61	0.66
RCOM	0.55	0.42	0.72	1.00	0.49	0.57
MAPT	0.75	0.52	0.61	0.49	1.00	0.68
MACH	0.70	0.57	0.66	0.57	0.68	1.00

all correlations were significant at $p < 0.05$

All correlations were greater than 0.09, thus, HYPOTHESIS 1 was rejected: the five intellectual variables were each significantly related to the criterion. Scatterplots (APPENDIX III) show that the correlations were substantial, linear and positive; hence, the computed values for correlations were reasonable.

Correlations between the Criterion CMAT and the five measures of academic achievement ranged from 0.55 to 0.75, with the two measures of prior mathematics performance correlating higher (0.70, 0.75) than the two global (I.Q.) measures (0.57, 0.65). The measure of Mathematics Aptitude achieved a higher correlation with the criterion than did the measure of Upper-Primary School Mathematics Achievement, while the measure of Non-Verbal I.Q. did not correlate as highly as did the measure of Verbal I.Q.. As expected, the correlation between the two measures of prior mathematics performance was high (0.68). Similarly, the correlation between the measures of Reading Comprehension and Verbal I.Q. was also high (0.72), and the correlation between the measures of Verbal I.Q. and Non-Verbal I.Q. was substantial (0.58).

While differences between correlations were substantial, z-ratios presented in TABLE 5.4 (p. 90) show that not all such differences were significant. The critical z-value for the sample was 1.96 (0.95 confidence interval).

TABLE 5.4

Matrix of z-Ratios for Correlations Between the Criterion
and Intellectual Variables

	MACH	MAPT	NVIQ	VIQ	RCOM
MACH	-	1.58	3.36 *	1.65	4.02 *
MAPT	1.58	-	4.47 *	2.96 *	4.96 *
NVIQ	3.36 *	4.47 *	-	1.93	0.59
VIQ	1.65	2.96 *	1.93	-	3.12 *
RCOM	4.02 *	4.96 *	0.59	3.12 *	-

* significant at $p < 0.05$

For Upper-Primary School Mathematics Achievement (MACH) and Mathematics Aptitude (MAPT), the z-ratio did not reach significance. Hence, HYPOTHESIS 2 (a) was not rejected: there was no significant difference with respect to efficiency in predicting Grade Seven Mathematics Achievement for the two measures of prior-mathematics performance.

Similarly, HYPOTHESIS 2 (b) was not rejected, although the z-ratio was only marginally below the critical value: Verbal I.Q. (VIQ) and Non-Verbal I.Q. (NVIQ) must be regarded as possessing equal efficiency in predicting the Criterion.

However, for Reading Comprehension (RCOM) and Verbal I.Q. (VIQ), the z-ratio was far above the required critical value of 1.96. HYPOTHESIS 2 (c) was rejected: the measure of Verbal I.Q. is significantly more efficient in predicting Grade Seven Mathematics Achievement than the measure of Reading Comprehension.

The results are somewhat equivocal with respect to HYPOTHESIS 2 (d). While Mathematics Aptitude was a significantly more efficient predictor than either Verbal I.Q. or Non-verbal I.Q., Upper-Primary School Mathematics Achievement was a significantly more efficient predictor than Non-verbal I.Q. only. Whether measures of prior mathematics performance were more efficient predictors of the Criterion

than global performance measures, depended not only on the significance of z-ratios determined for simple correlations, but also on the z-ratio determined for the composite variables (MACH + MAPT) and (NVIQ + VIQ).

Multiple R's were computed (Hopkins and Glass, 1978, p. 169) for each composite variable separately and for both composite variables taken together (TABLE 5.5, p. 94 ; TABLE 5.6, p. 97). From these values the correlation between the two composite variables was calculated (0.71955). The z-ratio for the two composite variables was determined to be 3.66, which was significantly greater than the critical value of 1.96. Hence, HYPOTHESIS 2 (d) was rejected. Measures of prior mathematics performance, taken together, were more efficient predictors of Grade Seven Mathematics Achievement than global performance measures, taken together.

In summary, the two measures of prior mathematics performance were significantly more efficient predictors of Grade Seven Mathematics Achievement than the two measures of global performance. The measures of prior mathematics performance were not significantly different in predictive efficiency, nor were the global performance measures. However, Verbal I.Q. was a more efficient predictor of the Criterion than Reading Comprehension.

5.3.4 Multiple Linear Regression Analysis

The analysis of zero-order correlations between the Criterion and intellectual variables does not answer research questions concerned with the contribution of particular intellectual variables to prediction of Grade Seven Mathematics Achievement. Stepwise multiple regression analysis was used to determine the contribution of intellectual variables to such prediction. Scatterplots of residuals for each of the analyses (APPENDIX XI) do not significantly depart from assumptions underlying the significance tests.

TABLE 5.5 (p. 94) summarizes the analysis for the two measures of prior mathematics performance, global performance measures taken together, and Reading Comprehension. The following observations were made.

Mathematics Aptitude (MAPT) accounted for 56.00% of variance in the Criterion. With Upper-Primary School Mathematics Achievement (MACH) then entered into the model equation, 62.86% of variance in the Criterion was accounted for, a rise of 6.86%, which was significant:

$$F = 55.74 > F_{.999, 1,302} = 11.2.$$

Overall, the regression using the two measures of prior mathematics performance was also significant:

$$F = 255.56 > F_{.999, 2,302} = 7.15$$

TABLE 5.5

Summary Table for Two Measures of Prior Mathematics
Performance, Global Performance Measures and
Reading Comprehension

VARIABLE	MULTIPLE R	R SQUARE	RSQ. CHANGE
MAPT	0.74835	0.56003	-
MACH	0.79284	0.62859	0.06858 *
(NVIQ + VIQ)	0.81276	0.66058	0.03199 *
RCOM	0.81401	0.66261	0.00203 +

* significant at $p < 0.001$

+ not significant at $p < 0.05$

Hence, HYPOTHESIS 3 (a) was rejected: Upper-Primary School Mathematics Achievement significantly predicted the Criterion beyond prediction already accounted for by Mathematics Aptitude.

From TABLE 5.5, it may also be seen that global performance measures accounted for 3.2% of variance in the Criterion, beyond variance already attributed to the two measures of prior mathematics performance. This contribution was significant:

$$F = 14.13 > F_{.999, 2, 300} = 7.15$$

The regression using the four intellectual variables was also significant:

$$F = 145.97 > F_{.999, 4, 300} = 4.81$$

Hence, HYPOTHESIS 3 (c) was also rejected: global performance measures significantly predicted Grade Seven Mathematics Achievement beyond prediction already accounted for by measures of prior mathematics performance.

From TABLE 5.6 (p. 97), HYPOTHESIS 3 (b) was rejected. Non-verbal I.Q. alone accounted for 33.06% of variance in the Criterion. With Verbal I.Q. entered into the model, an additional 15.02% of variance was accounted for, which was significant:

$$F = 88.72 > F_{.999, 1,302} = 11.2.$$

The overall regression using the two global performance measures was significant:

$$F = 140.83 > F_{.999, 2,302} = 7.15.$$

Similarly, HYPOTHESIS 3 (d) was rejected. The contribution of Reading Comprehension to prediction of the Criterion, beyond prediction already attributed to Verbal I.Q., was 1.24% (TABLE 5.7, p. 98). The contribution was significant

$$F = 6.62 > F_{.95, 1,302} = 3.89,$$

as was the overall regression

$$F = 116.26 > F_{.999, 2,302} = 7.15.$$

But, Reading Comprehension was not a significant predictor of the Criterion once the total contribution of both measures of prior mathematics performance and both measures of global performance was considered. From TABLE 5.5, the four variables accounted for 66.06% of variance, while Reading Comprehension only accounted for an additional 0.2% of variance:

$$F = 1.80 < F_{.95, 1,299} = 3.89.$$

Hence, HYPOTHESIS 3 (e) was not rejected.

TABLE 5.6Summary Table for Global Performance Measures

VARIABLE	MULTIPLE R	R SQUARE	RSQ. CHANGE
NVIQ	0.57495	0.33057	-
VIQ	0.69468	0.48258	0.15201 *

* significant at $p < 0.001$

TABLE 5.7Summary Table for Verbal I.Q. and Reading Comprehension

VARIABLE	MULTIPLE R	R SQUARE	RSQ. CHANGE
VIQ	0.65010	0.42263	-
RCOM	0.65955	0.43501	0.01238 *

* significant at $p < 0.05$

In summary, the analysis showed that Mathematics Aptitude was the best predictor of Grade Seven Mathematics Achievement, accounting for 56% of variance. But, the most efficient prediction of the Criterion was obtained by also utilising Upper-Primary School Mathematics Achievement (additional 6.8% of variance), and both I.Q. measures (a further 3.2%); Reading Comprehension did not contribute significantly beyond prediction already accounted for by prior mathematics/global performance measures. The four significant predictors together accounted for 66.06% of variance in the Criterion. Verbal I.Q. accounted for 15.02% of variance in addition to variance accounted for by Non-verbal I.Q. alone (33.06%), while Reading Comprehension contributed 1.24% of variance beyond variance accounted for by Verbal I.Q. (42.26%).

The value of the overall multiple correlation coefficient ($R = 0.81276$), using the four measures of prior mathematics performance and global performance, was sufficiently high to be confident that no major causal intellectual variables had been overlooked in the choice of predictors of Grade Seven Mathematics Achievement.

5.4 An Instrument for Prediction of Grade Seven Mathematics Achievement

A major aim of the study was the determination of a regression equation which would be suitable for prediction purposes. Such a "prediction" equation would assemble a linear combination of efficient intellectual variables which together provided the best prediction of the Criterion. The predicted achievement scores would then provide school administrators and teachers with the best estimate of students' mathematics abilities at the beginning of Grade Seven.

5.4.1 Description of Analysis Techniques

A prediction equation, determined by multiple linear regression techniques and used for predicting students' Grade Seven Mathematics Achievement, must be valid for data sets other than the set used to determine the equation. It is quite possible that studies examining the validity of the prediction equation during any one Grade Seven year may not accurately reflect the predictive validity of the equation over the more extended period of time during which it was proposed to utilise the equation.

In the study, two procedures were used to determine the validity of the prediction equation. The most commonly used measure of predictive validity is the "cross-validated r ",

that is, the Pearson product-moment correlation coefficient between the predicted and the actual scores. This coefficient is often compared with the multiple correlation coefficient R determined from the base year data set, a comparison which gives an indication of the accuracy and stability of the prediction equation. But, this statistic alone is not a guarantee of good prediction: a high cross-validated r may result even when predicted and actual scores are not highly related (Sawyer and Maxey, 1979; Motoyama and Wolins, 1980). A more cautious approach is to produce a scatterplot, of predicted and actual scores, which may be directly examined to determine if the correlation is linear, substantial and positive.

The study used response data collected during 1982 to determine the prediction equation. Using this "one-year-lag" prediction equation, "predicted" criterion scores were obtained from 1983 response data. Provided that assumptions concerning scatterplot of actual and predicted scores are satisfied, a high correlation between actual 1983 criterion scores and the corresponding predicted scores is evidence of good predictive validity of the prediction equation.

5.4.2 Choice of Predictors

In section 5.3, it was demonstrated that each of five intellectual variables was a substantial predictor of dependent

variable Grade Seven Mathematics Achievement. When the model under consideration was controlled for the four variables representing prior mathematics performance and global performance, the fifth variable Reading Comprehension was found to be not significant. The value of the overall multiple correlation coefficient ($R = 0.81276$) for this model was sufficiently high to be confident that no major causal variables had been overlooked.

Thus, the four variables representing prior mathematics performance and global performance form the initial set of predictors for the prediction equation. Whether all four variables form the final set of predictors will depend upon progressive results of data analysis.

Recall from section 5.3 that, for a variable to be a useful predictor of the Criterion, it was not sufficient for that variable alone to be highly correlated with the Criterion. Indeed, stepwise multiple regression procedures were utilised to determine the effect of the variable beyond the effects attributed to other variables already included in the model. Such a procedure resulted in Reading Comprehension being discarded as a predictor of Grade Seven Mathematics Achievement.

However, another factor must be taken into account in the choice of predictors: the set of predictors must be as

small as possible so that there is economy in any future collection of data for the regression equation but, with consideration given to the following points.

I.Q. data for beginning students will continue to be readily available. In the school, measures of Verbal I.Q. and Non-Verbal I.Q. are widely used throughout curricula in the identification of future learning success; the use of I.Q. measures as predictors of students' Grade Seven mathematics scores is but one application. Also, the I.Q. tests will continue to be a responsibility of the school guidance counsellor, and will therefore not directly add to the workload of teachers. The school will not be burdened with substantial costs associated with these tests - they will continue to be funded by the central authority. Since these tests are conducted during the latter part of Grade Six, they do not involve additional disruption to school routine during the busy initial period of Grade Seven.

Hence, the final set of predictors should include both Verbal I.Q. and Non-Verbal I.Q..

In Chapter 2, and reviewed again in Chapter 3, it was argued that since primary schools are known to teach mathematics in different ways, Grade Six students are likely to possess a variety of mathematics backgrounds. This factor tends to invalidate the use of an achievement test of Grade Six

mathematics: measures of Upper-Primary School Mathematics Achievement may substantially reflect the mathematics curriculum and teaching style of individual primary schools. This would not be the case with measures of Mathematics Aptitude, which would tend to reflect a student's knowledge and understanding of processes which are the foundation of general knowledge in mathematics. This notion was supported by the results in sections 5.3.3 and 5.3.4: Mathematics Aptitude was more highly correlated with the Criterion than was Upper-Primary School Mathematics Achievement, although the difference did not reach statistical significance; and Mathematics Aptitude substantially predicted the Criterion in addition to prediction already attributed to Upper-Primary School Mathematics Achievement.

Hence, the final set of predictors would include Mathematics Aptitude before Upper-Primary School Mathematics Achievement.

In summary then, the prediction equation would utilise a set of predictors, initially consisting of both global performance measures and both prior mathematics performance measures, but finally determined according to criteria of economy, practicality, and causal relationship to the Criterion.

5.4.3 Determination of the Regression Equation

The first stage in the analysis utilised regression techniques to determine the effect upon Grade Seven Mathematics Achievement of each of the four predictors Upper-Primary School Mathematics Achievement, Mathematics Aptitude, Non-Verbal I.Q. and Verbal I.Q. The order of entry of predictors into the model equation was NVIQ, VIQ, MAPT, MACH.

In section 5.2.1, it was concluded that samples employed in the study were not significantly different. In section 5.3.4, it was demonstrated that scatterplots of residuals for stepwise regression analyses did not substantially violate assumptions underlying significance tests. Hence, it was reasonable to conclude that similar stepwise procedures in this section would also not violate the same assumptions.

From TABLE 5.8 (p.107), it may be seen that:

1. NVIQ alone accounts for 45.42% of variance in the Criterion, which was significant

$$F = 125.64 > F_{0.999, 1, 151} = 11.4.$$

2. VIQ accounts for an additional 7.44% of variance beyond that attributed to NVIQ, which was significant

$$F = 23.68 > F_{0.999, 1, 150} = 11.4.$$

3. MAPT accounts for an additional 11.76% of variance beyond that attributed to the two global performance measures

taken together, which was significant

$$F = 49.52 > F_{0.999, 1, 149} = 11.4.$$

4. MACH accounts for an additional 1.57% of variance beyond that attributed to Mathematics Aptitude and the two global performance measures taken together, which was significant

$$F = 6.92 > F_{0.99, 1, 148} = 6.85.$$

Also from TABLE 5.8, the standardised regression weights demonstrate the relative contribution of each predictor to the full model.

The weight for Mathematics Aptitude is the largest by far, and demonstrates the overwhelming importance of this predictor - the measure of students' understanding of mathematical operations is the most important causal variable in the model. The weight for Non-Verbal I.Q. is also substantial, thus demonstrating the importance of this measure of global performance to the model. While the weights for Verbal I.Q. and Upper-Primary School Mathematics Achievement are not as substantial as the other two predictors, they are significant causal variables.

However, Upper-Primary School Mathematics Achievement only accounted for an additional 1.57% of variance in the Criterion, beyond variance already accounted for by the other

TABLE 5.8

Summary Table for Measures of Prior Mathematics
Performance and Global Performance

(1982 Sample, N = 153 cases)

VARIABLES	MULTIPLE R	R SQUARE	RSQ CHANGE	BETA
NVIQ	0.67392	0.45417	0.45417	0.26080
VIQ	0.72704	0.52858	0.07442 *	0.11136
MAPT	0.80386	0.64618	0.11760 *	0.38029
MACH	0.81356	0.66188	0.01569 +	0.19617

* significant at $p < 0.001$

+ significant at $p < 0.01$

three variables. In section 5.4.3, it was noted that data for this variable were obtained from testing (ACER CATIM 6/7) during the early part of the Grade Seven year, with accompanying financial cost to the school, disruption of Grade Seven classes, and additional work in testing, marking and interpretation for Grade Seven teachers. It was argued that unless MACH contributed substantially to prediction of the Criterion, it would be appropriate to drop the variable from the model. Clearly, with a contribution of only 1.57%, MACH did not substantially predict Grade Seven Mathematics Achievement beyond prediction already accounted for by NVIQ, VIQ, and MAPT. Consequently, MACH was dropped from the model.

With MACH deleted from the model, the 1982 sample varied marginally. Summary data for the three-predictor model is presented in TABLE 5.9 (p. 109). From TABLE 5.9, it was clear that there was no significant difference attributable to the marginal change in sample size. As expected, the regression was significant:

$$F = 282.87 > F_{0.999, 1, 154} = 11.4.$$

Hence, the prediction equation was:

$$\hat{Y}_i = -64.23 + 0.50*(NVIQ)_i + 0.22*(VIQ)_i + 1.51*(MAPT)_i$$

TABLE 5.9

Summary Table for the Two Global Performance
Measures and Mathematics Aptitude

(1982 Sample, N = 158)

VARIABLE	MULTIPLE R	R SQUARE	RSQ. CHANGE	B
NVIQ	0.67549	0.45628	0.45628	0.50002
VIQ	0.72758	0.52937	0.07309	0.21786
MAPT	0.64749	0.64749	0.11811	1.51418
CONSTANT	-	-	-	-64.23090

where: \hat{Y}_i denotes the "predicted" Grade Seven Mathematics Achievement score of the i th. student, and symbols for each of the other variables have their usual meaning.

5.4.4 Validity of the Prediction Equation

In the study, two procedures were used to determine the validity of the prediction equation. Firstly, the most commonly used measure of predictive validity is the "cross-validated r ", that is, the Pearson product-moment correlation coefficient between the predicted and the actual scores for a data set not used to determine the original equation.

Secondly, the cross-validated r alone is not a guarantee of good prediction because of a possible non-linear relationship between predicted and actual scores. Motoyama and Wolins (1980, p. 942) in their review of indicators of good prediction, noted that "...it is important to recognize first of all that the main consideration in goodness of prediction rests upon cross-validation." Sawyer and Maxey (1979, p. 281) illustrated the limitation of this statistic with hypothetical scatterplots, which possessed very high correlations, but intractable non-linearity. The relationship between predicted and actual scores is confirmed if the scatterplot is directly examined and determined to be substantial, linear and positive.

The study used response data collected during 1982 to determine the prediction equation. Using this "one-year-lag" prediction equation, "predicted" criterion scores were obtained from 1983 response data and the correlation between predicted and actual scores determined to be:

$$\text{cross-validated } r = 0.78444.$$

The value for the cross-validated r may be compared with the multiple correlation coefficient R obtained for the 1983 sample utilising the three variables NVIQ, VIQ and MAPT. TABLE 5.10 (p.112) summarizes regression data for the 1983 sample.

From TABLE 5.10, it may be seen that the multiple R is 0.80588; hence, the cross-validated r (0.78444) exhibits only minimal shrinkage.

The scatterplot for predicted scores and actual scores is presented in APPENDIX V . Direct examination of the scatterplot reveals a substantial, positive, linear relationship with few outliers. Hence, the prediction equation may be accepted as a valid instrument for determining students' expected Grade Seven mathematics scores.

This aspect of the present study demonstrated that the correlation between predicted and actual scores was

TABLE 5.10Summary Table for the Two Global Performance
Measures and Mathematics Aptitude(1983 Sample, N = 155)

VARIABLES	MULTIPLE R	R SQUARE	RSQ. CHANGE
NVIQ	0.49373	0.24377	0.24377
VIQ	0.69222	0.47917	0.23540 *
MAPT	0.80588	0.64944	0.17027 *

* significant at $p < 0.001$

consistently high and stable when cross-validated over a one-year period. The prediction equation, utilising Non-Verbal I.Q., Verbal I.Q. and Mathematics Aptitude, provided a good estimate of Grade Seven Mathematics Achievement for the 1983 sample. Expected scores determined by the prediction equation will also be the best estimate of students' mathematics abilities at the beginning of the Grade Seven year.

CHAPTER 6

SUMMARY, INTERPRETATION AND IMPLICATIONS
FOR FURTHER RESEARCH	114

6.1 Need for the Study	114

The present study arose from concern that there was a lack of continuity of mathematics curricula, between a state secondary school and its feeder primary schools. This lack of continuity impacted severely in the beginning year of secondary school and was reflected in a paucity of performance data on students entering the secondary school. It was felt that the lack of performance data had often resulted in inadequate decision-making for Grade Seven students by school personnel concerning a range of school-situational factors such as remedial teaching, special curriculum offerings, ability groupings, etc., and generally poor planning of mathematics curricula by Grade Seven teachers so that many students were disadvantaged by inappropriate mathematics curricula at an important stage of schooling.

This effect was exacerbated by several other factors, notably the general broadening of the curriculum base from Grade Six to Grade Seven, the specialization of secondary school curricula, and the need to allocate increasingly limited secondary school resources to those students most in need.

Finally, it is believed that schools do not make sufficient use of the results of educational research. While research concerned with aptitude - treatment interactions is often the basis for decisions concerning school-situational factors in middle- and upper-secondary school, such research is not applied to lower-secondary school. This is due almost entirely to lack of performance data for Grade Seven students. Aptitude -treatment interactions in mathematics education are widely reported in the literature. With a valid measure of students' mathematics abilities, this research can be applied to students at an important stage of schooling.

A major aim of the study was to determine an instrument which would predict students' mathematics achievement at the end of Grade Seven, and thereby provide a measure of individual mathematics ability at the beginning of Grade Seven. Such a measure would fill the gap in performance data for beginning students, lead to improved decision-making by school administrators and the guidance counsellor, allow teachers to better plan the Grade Seven mathematics curriculum to take account of student' prior mathematics skills and knowledge, and provide a data base which may be utilised to apply the results of mathematics aptitude - treatment research.

While the second aim of the study had less immediate practical application to the school, it did have important

implications for research into learning processes in mathematics. The knowledge of which variables substantially predict Grade Seven mathematics achievement is of potentially great significance to educators since prediction of individual learning success in mathematics may lead to greater understanding of the learning processes involved, and their effects.

6.2 Review of Results

6.2.1 Predictive Efficiency of Intellectual Variables

The review of relevant literature suggested that one of the reasons why previous prediction studies of lower-secondary school mathematics achievement had been generally unsuccessful was the choice of inappropriate predictors. The domain of measurement from which predictors were drawn was shown to be important. Studies which utilised predictors drawn from the biographic or dispositional domains of measurement were generally unsuccessful in substantially predicting the criterion measure of mathematics achievement. Studies which used intellectual predictors were more successful.

Within the intellectual domain, studies have utilised a multitude of intellectual predictors covering a wide range of skills: global measures of aptitude and achievement, measures of reading comprehension and mathematics aptitude and achievement variables, were often employed as predictors. It

was argued that an effective approach to predicting lower-secondary school mathematics achievement may lie in combining efficient intellectual predictors to produce the best prediction of the criterion.

The results of some studies suggested strongly that students' mathematics achievement at upper-primary school was the best predictor of their lower-secondary school mathematics achievement, but in Tasmanian schools mathematics curricula at either the upper-primary school or lower-secondary school stages are known to vary greatly in content and teaching method, factors which militate against the use of a common measure of upper-primary school mathematics achievement.

Some studies reported the use of predictors which measure mathematics aptitude and mathematics achievement. On the basis of this evidence, it was expected that the use of mathematics aptitude measures, as well as measures of mathematics achievement, may overcome the problem of the variety of mathematics curricula and teaching methods employed at the upper-primary school and lower-secondary school stages: the measure of mathematics aptitude would be largely independent of individual school differences.

The results of the present study support this notion: the measure of mathematics aptitude was more highly correlated with the Criterion than the measure of mathematics achievement,

but the difference was not statistically significant. The prediction equation determined from the 1982 sample provides additional support for the notion. The measure of mathematics achievement did not substantially predict the Criterion beyond prediction attributed to mathematics aptitude and both I.Q. measures. While the measure of mathematics achievement would be an asset to Grade Seven teachers - it might be used as a screening instrument to determine deficiencies in skill/knowledge areas, it would hardly be worthwhile employing such a measure as a predictor.

In addition to measures of mathematics achievement and mathematics aptitude, a number of studies had utilised measures of verbal I.Q. and non-verbal I.Q.. The results of this study demonstrated that the two measures of prior mathematics performance taken together, were significantly more efficient predictors of Grade Seven Mathematics Achievement than the two measures of global performance taken together.

It was argued that the Grade Seven mathematics curriculum is relatively independent of verbal skills. This suggested that non-verbal I.Q. may be a better predictor of Grade Seven Mathematics achievement than a measure of verbal I.Q.. This notion was not supported by the results from the present study. The Criterion was better predicted by the measure of verbal I.Q. than non-verbal I.Q., but the difference did not reach significance. The verbal component of Grade

Seven mathematics must be more substantial than indicated by the results of previous studies.

One study also utilised a measure of reading comprehension as a predictor. Given the assumed poor relationship between Grade Seven mathematics achievement and verbal skills, a measure of reading comprehension may contribute very little towards explaining variance in the criterion, once verbal I.Q. has been taken into consideration. In the present study, the measure of verbal I.Q. was a more efficient predictor of the Criterion than the measure of reading comprehension. Consequently, the latter measure was a redundant variable, being already included in verbal I.Q..

Previous studies had mixed success in achieving high multiple correlation coefficients. In the present study, the analysis showed that the measure of mathematics aptitude was the best predictor of students' individual Grade Seven mathematics achievement, accounting for 56% of variance. But, the most efficient prediction of the Criterion was obtained by also utilising prior mathematics achievement (additional 6.8% of variance), and both I.Q. measures (a further 3.2%); the measure of reading comprehension did not contribute significantly beyond prediction already accounted by prior mathematics/global performance measures. The four significant predictors together accounted for 66.06% of variance in the Criterion.

This result is a substantial improvement on nearly all previous studies, and is the best result for this type of study to date. Best previous results of prediction of lower-secondary school mathematics achievement include Youngman (1980) - 63% for his "city" sample; Dossey and Jones (1980) - 60% for their "mathematics concepts criterion"; and Taylor, Brown and Michael (1976) - 47% of their criterion, algebra + geometry achievement.

6.2.2 Prediction Instrument

Measures of global performance and prior mathematics performance were substantially correlated with students' mathematics achievement at the end of Grade Seven, but separately, they provided inadequate predictive information concerning students' learning success during Grade Seven. While measures of upper-primary school mathematics performance (aptitude and achievement) provided more information than global performance measures, a economic set of these predictors provided the best estimate of a student's learning success. This best estimate of learning success is also the best measure of a student's mathematics ability at the beginning of Grade Seven, and is given by the prediction equation:

$$\hat{Y}_i = -64.23 + 0.50*(NVIQ)_i + 0.22*(VIQ)_i + 1.51*(MAPT)_i$$

where the symbols have their usual meaning.

The equation satisfied the usual criteria for predictive validity: the validity coefficient or cross-validated r , for the one-year lag, was high; the scatterplot of predicted scores and actual scores showed that the correlation was linear, positive and consistent with the calculated value; the cross-validated r exhibited only marginal shrinkage with the multiple- R for the actual scores.

Estimated achievement scores determined by the prediction equation depend on only three prior measures: non-verbal I.Q., as measured by the ACER STANDARD PROGRESSIVE MATRICES; verbal I.Q., measured by the ACER TOLA 6; and mathematics aptitude, measured by the ACER OPERATIONS TEST. Both I.Q. measures have been part of secondary school performance data for some years; they will continue to be utilised in the near future. Data for the OPERATIONS TEST might be collected by feeder primary schools toward the end of Grade Six, but if this cannot be achieved, then the test may be conducted during the first week of Grade Seven.

6.3 Research Design Problems

Due to the nature of the research questions under investigation in the study, it was necessary to test the population of students enrolled in Grade Seven during 1982 and 1983, thus encompassing the entire ability range encountered in the school.

This led to some problems with one test instrument: the GAP READING COMPREHENSION TEST was unsuitable for testing reading comprehension of students towards the end of Grade Six. The test did not discriminate amongst good readers, and hence, the distribution of scores was skewed towards the top of the range.

Despite the robustness of regression with respect to violations of normality, this departure from normality was substantial and may have influenced some results concerned with regression, but since the measure of reading comprehension was dropped from the whole data sample model and the 1982 sample model, it did not subsequently influence final results and the validity of conclusions drawn from those results.

An alternative measure of reading comprehension, such as the ACER GAPADOL READING COMPREHENSION TEST, may have been more appropriate for this study. This test is widely available and is a valid measure of reading comprehension, but at this time does not appear to be widely accepted by guidance counsellors as a measure of reading comprehension in upper-primary school, and consequently is not widely used. It must be remembered that where future use of a prediction instrument is considered, availability of data for the predictors is always an important consideration. For this study, only the GAP READING COMPREHENSION TEST was suitable for this purpose.

The question of external validity is more difficult to assess. The samples used in the study were drawn from a state high school situated in a relatively homogeneous socio-economic area, which is predominantly middle-class; the school, while regarded as essentially traditional in its philosophy, is nevertheless fairly typical of most secondary schools in Tasmania.

However, it is different from all other high schools in that it is the only all-boys high school. Sex differences in learning success in mathematics is a continuing theme in the research, with many studies focusing on the question of different cognitive development of boys and girls (Taplin, 1982).

The present study used the ACER OPERATIONS TEST to measure mathematics aptitude of subjects. This test, based upon Collis' 1975 study of concrete and formal operations in school mathematics, is a measure of cognitive development, but in the area of mathematics operations. Hence, the results of the present study should be generalizable to other high schools where the Grade Seven population consists of boys and girls.

The results of predictive validity studies are always open to questions concerning the stability of prediction equations over time. The results of such studies are more

acceptable when validity coefficients are calculated over several years, rather than over only one year. With only a one-year lag, there is a risk that the cross-validated r may shrink significantly in succeeding years.

6.4 Implications for Further Research

The findings of this study were in general agreement with the findings of other studies into predictors of lower-secondary school mathematics achievement. In fact, the uniformity of findings of this study and previous studies makes extended discussion redundant. Probably the main point to stress is the importance of the measure of mathematics aptitude as a predictor of Grade Seven mathematics achievement.

This measure was more highly correlated with the criterion than was the measure of prior mathematics achievement. This finding was perhaps surprising, even though it logically followed from knowledge of the variety of mathematics curricula in feeder primary schools.

The importance of this finding for research in mathematics education lies in its implications for the underlying causes of learning success in mathematics: learning processes in mathematics, at lower-secondary school, appear to be more closely related to knowledge of number and understanding of mathematical operations than to general

mathematical skills.

Future research in this area might profitably examine the ACER OPERATIONS TEST and the CRITERION MATHEMATICS ACHIEVEMENT TESTS to determine which aspects of both tests most closely correlate, and hence, focus more closely on those notions of number and operation which are the basis of learning success in mathematics. This line of research is not new. Collis' (1975) study, and his subsequent determination of the SOLO TAXONOMY, would be useful starting points.

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APPENDIX ITest Instruments

Criterion Mathematics Achievement Tests - 1982 and 1983 Versions

ACER Class Achievement Test in Mathematics CATIM 6/7

ACER Mathematics Profile Series OPERATIONS TEST

NEW TOWN HIGH SCHOOL

GRADE 7

MATHEMATICS
NOVEMBER 1982

TIME: 2 periods.

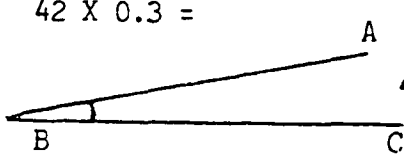
NAME: _____

CLASS: _____

SECTION A

Write your answers in the spaces provided.

ANSWERS.

1. $7 \times 9 =$
2. $36 - 19 =$
3. $120 + 20 =$
4. $74 + 29 =$
5. $24 \times 5 =$
6. Find the sum of 593 and 188.
7. Find the product of 19 and 17.
8. $452 \times 0 =$
9. $\$3.24 + 48¢ + \$1.12 =$
10. Find the difference between 808 and 219
11. What is $\frac{1}{4}$ of 84 kg.?
12. $a + 2a + a =$
13. How many cm in $1\frac{3}{4}$ m.?
14. How many degrees in a right angle?
15. $\$5.21 - \$2.75 =$
16. Write the number for five million, two hundred and ten thousand, three hundred and one.
17. If $m = 7$ find $m^2 + 1$.
18. $\sqrt{100} =$
19. $\frac{9}{7} - \frac{2}{7} =$
20. How many days in 3 years?
21. How many g in 1.6 kg.?
22. $3^3 =$
23. If $a = 6$, find the value of $2a + 5$
24. $42 \times 0.3 =$
25.  $\angle ABC$ is closest to 90° or 30° .

1.
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NAME: _____

CLASS: _____

ANSWERS

- | | | | |
|-----|--|-----|-------|
| 26. | $\frac{3}{5} + \frac{3}{5} =$ | 26. | |
| 27. | Cancel down this fraction to its simplest form.
$\frac{24}{36}$ | 27. | |
| 28. | Write the reciprocal of $\frac{1}{5}$ | 28. | ..... |
| 29. | $8.1 \div 0.9 =$ | 29. | ..... |
| 30. | $\frac{1}{5}$ of 20.4 = | 30. | ..... |
| 31. | If \$8.75 is divided equally amongst 7 people, how much will each one get? | 31. | ..... |
| 32. | $8.16 \times 1000 =$ | 32. | ..... |
| 33. | $9.4 \div 100 =$ | 33. | ..... |
| 34. | $1.95 \times 10 =$ | 34. | ..... |
| 35. | Change 1.26 km to m. | 35. | ..... |
| 36. | Write the reciprocal of $1\frac{2}{3}$ | 36. | ..... |
| 37. | How many degrees in the angles of a triangle? | 37. | ..... |
| 38. | $4a \times 7b =$ | 38. | ..... |
| 39. | $27xy \div 3y =$ | 39. | ..... |
| 40. | How many minutes between 11.05 p.m. and 2.27 a.m.? | 40. | ..... |
| 41. | $6x^2 + 2x^2 =$ | 41. | ..... |
| 42. | If $a = 2$, $b = -1$, what does $b^2 + 2a =$ | 42. | ..... |
| 43. | Express $\frac{17}{100}$ as a decimal. | 43. | ..... |
| 44. | Write 0.56 as a fraction in its simplest form. | 44. | ..... |
| 45. | $-26 > -11$ True or false? | 45. | ..... |
| 46. | If bananas are \$1.68 for 1 kg., how much will $1\frac{1}{2}$ kg. cost? | 46. | ..... |
| 47. | Round off 186.419 to 2 decimal places. | 47. | ..... |
| 48. | Find the area of a square of side 9 cm. | 48. | ..... |
| 49. | $26 \div 8 \div 2 = 17$ True or false? | 49. | ..... |
| 50. | How many degrees in 2 complete circles? | 50. | ..... |

NAME: _____

CLASS: _____

SECTION B

$$\begin{array}{r} 51. \quad 4639 \\ \quad 370 \\ \quad 17 \\ + \quad 3461 \\ \hline \end{array}$$

$$\begin{array}{r} 52. \quad 15363 \\ - \quad 2874 \\ \hline \end{array}$$

$$\begin{array}{r} 53. \quad 137 \\ \times 18 \\ \hline \end{array}$$

$$54. \quad 13 \overline{) 4661}$$

$$\begin{array}{r} 55. \quad 87.909 \\ \quad 1.88 \\ + \quad 13.7 \\ \hline \end{array}$$

$$\begin{array}{r} 56. \quad 26.29 \\ - \quad 4.91 \\ \hline \end{array}$$

$$\begin{array}{r} 57. \quad 21.25 \\ \times 4.6 \\ \hline \end{array}$$

$$58. \quad 8 \overline{) 32.8}$$

$$59. \quad 0.5 \overline{) 2.55}$$

$$60. \quad 2\frac{4}{7} + 1\frac{5}{7}$$

$$61. \quad 1\frac{1}{2} + \frac{1}{4}$$

$$62. \quad 2\frac{3}{4} - 1\frac{1}{4}$$

$$63. \quad \frac{3}{8} \times \frac{4}{5}$$

$$64. \quad \frac{1}{5} \div \frac{1}{10}$$

NAME: _____

CLASS: _____

65. $2x + 10x$

66. $3(x + y)$

67. $18y + 12xy - 14xy$

68. $x(2 + y - a)$

69. Solve for x

$$x + 11 = 17$$

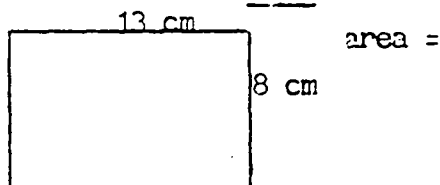
70. Solve for x

$$3x = 18$$

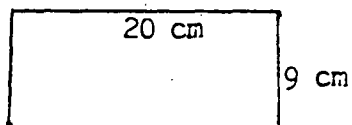
71. Solve for x

$$\frac{x}{4} = 5$$

72. Find the area of this rectangle.

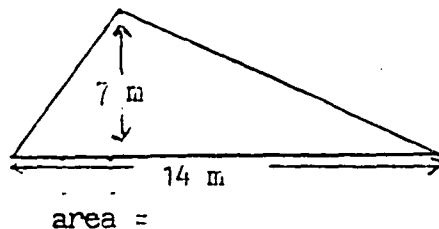


73. Find the perimeter of this rectangle.



perimeter =

74. Work out the area of this shape.



GRADE 7 MATHEMATICS

NAME: _____

CLASS: _____

SECTION C

Answer on a sheet of paper.

Set out all working carefully and neatly.

Evaluate:

75. $-4 + +6$

76. $-56 \div -7$

77. $-3 \times -4 \times -5$

Simplify:

78. $3\frac{1}{2} \times 2\frac{4}{5}$

79. $1\frac{3}{10} \div 5\frac{1}{5}$

80. $2 - \frac{6}{7} \div \frac{5}{7}$

Solve these equations.

81. $5(x + 4) = 10$

82. $2(x - 3) = 9$

83. $\frac{x}{5} - 2 = 0$

If $a = 3$, $b = 0.2$, $c = 0$, $d = 4$, $e = \frac{1}{2}$ find the value of

84. $d + a$

85. $2b + a$

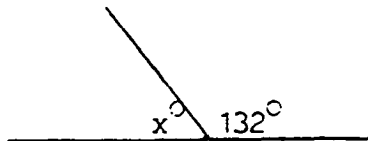
86. a^c

87. $(ad)^2$

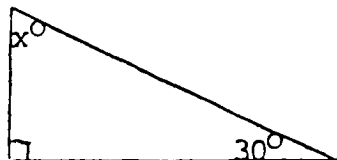
88. $(a + c)^e$

Find the value of x in the following diagrams.

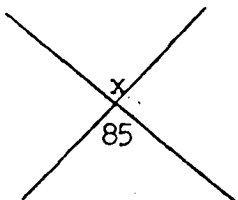
89.



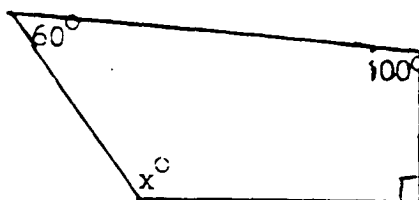
90.



91.



92.



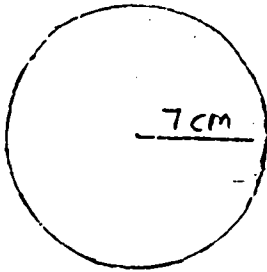
GRADE 7 MATHEMATICS

NAME: _____

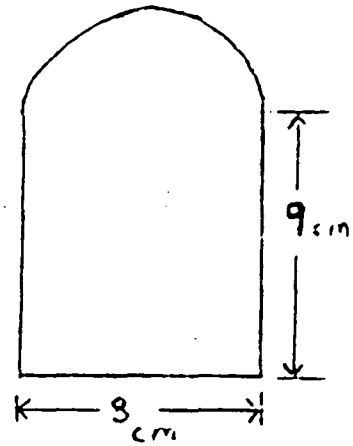
CLASS: _____

Find the area and perimeter of these shapes.

93.

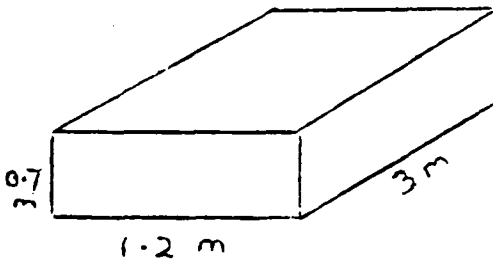


94.

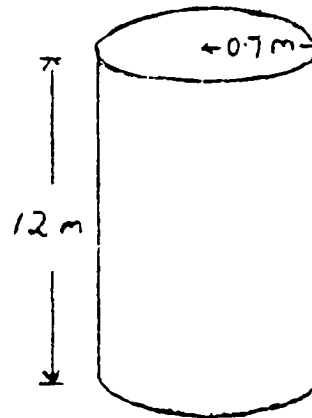


Find the volume of each of these shapes.

95.



96.



GRADE 7

MATHEMATICS

TIME: 2 periods.

NOVEMBER 1983

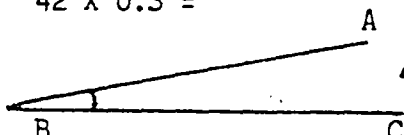
NAME: _____

CLASS: _____

SECTION A

Write your answers in the spaces provided.

ANSWERS.

- | | |
|---|----------|
| 1. $7 \times 9 =$ | 1. |
| 2. $36 - 19 =$ | 2. |
| 3. $120 + 20 =$ | 3. |
| 4. $74 + 29 =$ | 4. |
| 5. $24 \times 5 =$ | 5. |
| 6. Find the sum of 593 and 188. | 6. |
| 7. Find the product of 19 and 17. | 7. |
| 8. $452 \times 0 =$ | 8. |
| 9. $\$3.24 + 48¢ + \$1.12 =$ | 9. |
| 10. Find the difference between 808 and 219 | 10. |
| 11. What is $\frac{1}{4}$ of 84 kg.? | 11. |
| 12. $a + 2a + a =$ | 12. |
| 13. How many cm in $1\frac{3}{4}$ m.? | 13. |
| 14. How many degrees in a right angle? | 14. |
| 15. $\$5.21 - \$2.75 =$ | 15. |
| 16. Write the number for five million, two hundred and ten thousand, three hundred and one. | 16. |
| 17. If $m = 7$ find $m^2 + 1$. | 17. |
| 18. $\sqrt{100} =$ | 18. |
| 19. $\frac{9}{7} - \frac{2}{7} =$ | 19. |
| 20. How many days in 3 years? | 20. |
| 21. How many g in 1.6 kg.? | 21. |
| 22. $3^3 =$ | 22. |
| 23. If $a = 6$, find the value of $2a + 5$ | 23. |
| 24. $42 \times 0.3 =$ | 24. |
| 25.  $\angle ABC$ is closest to 90° or 30° . | 25. |

NAME: _____

CLASS: _____

ANSWERS

26. $\frac{3}{5} + \frac{3}{5} =$

26.
27. Cancel down this fraction to its simplest form.
 $\frac{24}{36}$

27.
28. Write the reciprocal of $\frac{1}{5}$

28.
29. $8.1 \div 0.9 =$

29.
30. $\frac{1}{5}$ of 20.4 =

30.
31. If \$8.75 is divided equally amongst 7 people, how much will each one get?

31.
32. $8.16 \times 1000 =$

32.
33. $9.4 \div 100 =$

33.
34. $1.95 \times 10 =$

34.
35. Change 1.26 km to m.

35.
36. Write the reciprocal of $1\frac{2}{3}$

36.
37. How many degrees in the angles of a triangle?

37.
38. $4a \times 7b =$

38.
39. $27xy \div 3y =$

39.
40. How many minutes between 11.05 p.m. and 2.27 a.m.?

40.
41. $6x^2 + 2x^2 =$

41.
42. If $a = 2$, $b = -1$, what does $b^2 + 2a =$

42.
43. Express $\frac{17}{100}$ as a decimal.

43.
44. Write 0.56 as a fraction in its simplest form.

44.
45. $-26 > -11$ True or false?

45.
46. If bananas are \$1.68 for 1 kg., how much will $1\frac{1}{2}$ kg. cost?

46.
47. Round off 186.419 to 2 decimal places.

47.
48. Find the area of a square of side 9 cm.

48.
49. $26 + 8 \div 2 = 17$ True or false?

49.
50. How many degrees in 2 complete circles?

50.

NAME: _____

CLASS: _____

SECTION B

$$\begin{array}{r} 51. \quad 4639 \\ \quad 370 \\ \quad 17 \\ \div \quad \underline{3461} \end{array}$$

$$\begin{array}{r} 52. \quad 15363 \\ - \quad \underline{2874} \end{array}$$

$$\begin{array}{r} 53. \quad 137 \\ \quad \times 18 \\ \hline \end{array}$$

$$54. \quad 13 \overline{) 4641}$$

$$\begin{array}{r} 55. \quad 87.909 \\ \quad 1.88 \\ \div \quad \underline{13.7} \end{array}$$

$$\begin{array}{r} 56. \quad 26.29 \\ \quad \underline{4.91} \end{array}$$

$$\begin{array}{r} 57. \quad 21.25 \\ \quad \underline{4.6} \end{array}$$

$$58. \quad 8 \overline{) 32.8}$$

$$\begin{array}{r} 59. \quad 0.5 \overline{) 2.55} \end{array}$$

$$60. \quad 2\frac{4}{7} + 1\frac{5}{7}$$

$$61. \quad 1\frac{1}{2} + \frac{1}{4}$$

$$62. \quad 2\frac{3}{4} - 1\frac{1}{4}$$

$$63. \quad \frac{3}{8} \times \frac{4}{5}$$

$$64. \quad \frac{1}{5} \div \frac{1}{10}$$

NAME: _____

CLASS: _____

65. $2x + 10x$

66. $3(x + y)$

67. $18y + 12xy - 14xy$

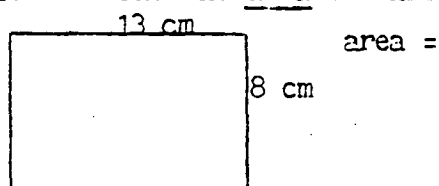
68. $x(2 + y - a)$

69. Solve for x
 $x + 11 = 17$

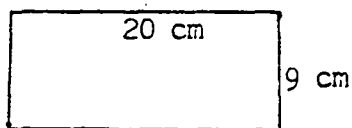
70. Solve for x
 $3x = 18$

71. Solve for x
 $\frac{x}{4} = 5$

72. Find the area of this rectangle.

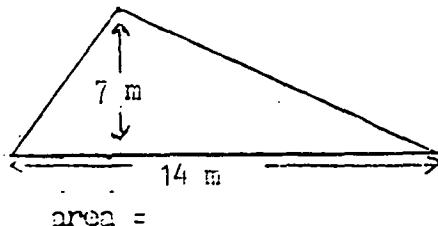


73. Find the perimeter of this rectangle.



perimeter =

74. Work out the area of this shape.



NAME: _____

CLASS: _____

SECTION C

Answer on a sheet of paper.

Set out all working carefully and neatly.

Evaluate:

75. $-4 + +6$

76. $-56 \div -7$

77. $-3 \times -4 \times -5$

Simplify:

78. $3\frac{1}{2} \times 2\frac{4}{5}$

79. $1\frac{3}{10} \div 5\frac{1}{5}$

80. $2 - \frac{6}{7} \div \frac{5}{7}$

Solve these equations.

81. $5(x + 4) = 10$

82. $2(x - 3) = 9$

83. $\frac{x}{5} - 2 = 0$

If $a = 3$, $b = 0.2$, $c = 0$, $d = 4$, $e = \frac{1}{2}$ find the value of

84. $d + a$

85. $2b + a$

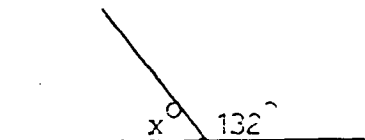
86. a^c

87. $(ad)^2$

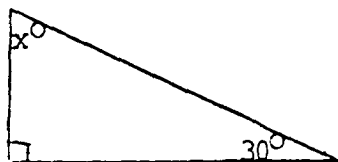
88. $(a + c)^e$

Find the value of x in the following diagrams.

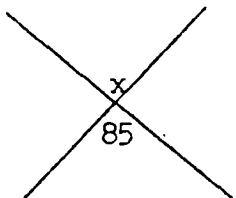
89.



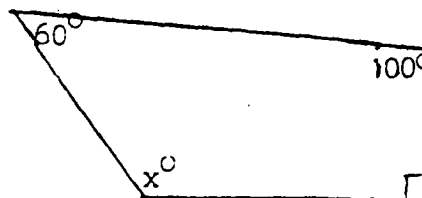
90.



91.



92.



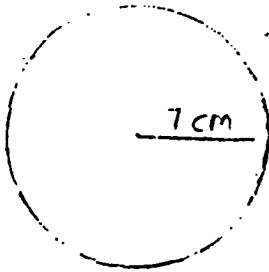
GRADE 7 MATHEMATICS

NAME: _____

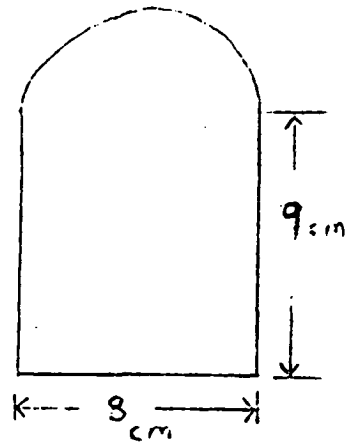
CLASS: _____

Find the area and perimeter of these shapes.

93.

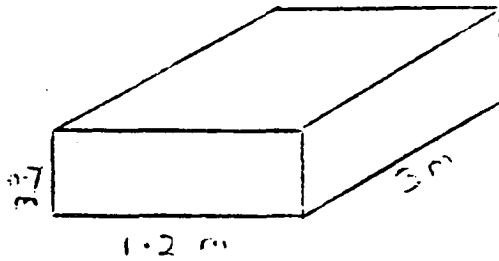


94.

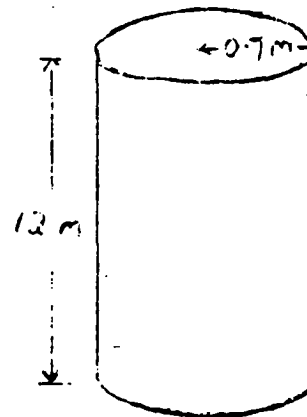


Find the volume of each of these shapes.

95.



96.

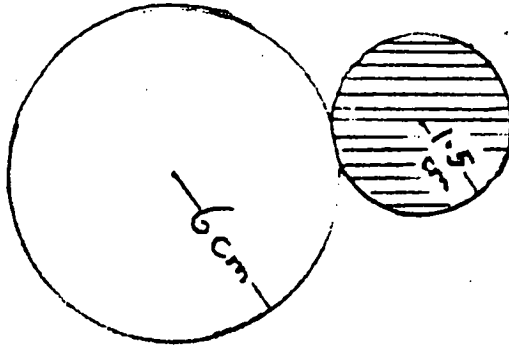


EXTENSION QUESTIONS:

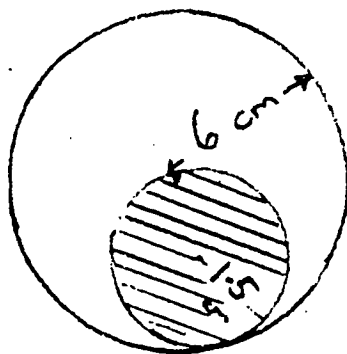
Only try these questions if you have done all the others.

Set out any working-out you use to answer the question, or, write down in words how you would work these questions out.

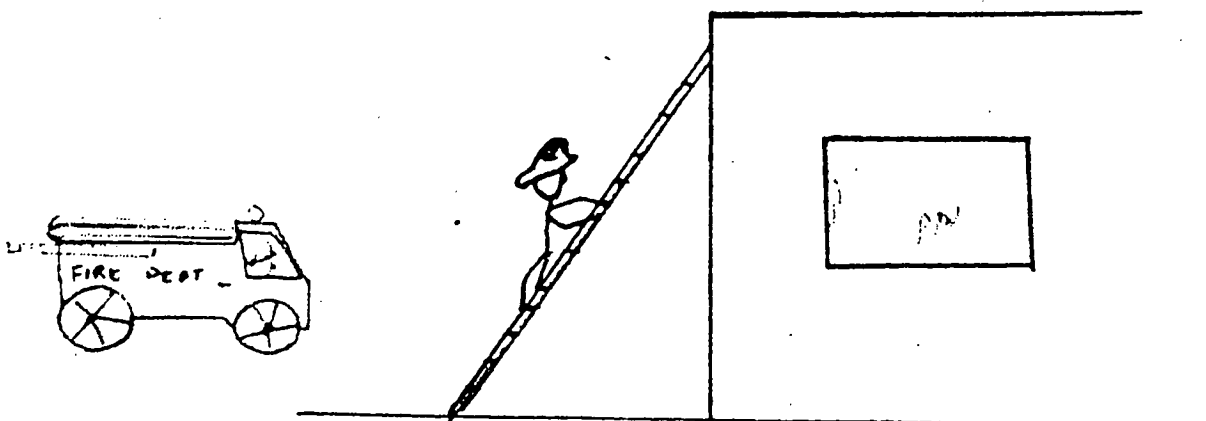
97. (i) In the diagram below, A and B are two wheels. Wheel B rolls around the outside of wheel A. How many times will wheel B turn if it rolls completely around the outside of A?



- (ii) If B were inside A, how many times would it turn if it rolled completely around the inside of A (given that in this case the inside radius of A is also 6 cm.)?



98. A fireman stood on the middle rung of his ladder spraying water into a burning building. As the blaze lessened he climbed up 5 rungs. A sudden flare up sent him down 10 rungs. When it died down he moved back up 12 rungs. When the fire was out he climbed the remaining 10 rungs to the top of the ladder and entered the building. How many rungs did the ladder have?



australian council for educational research

CATIM

class achievement test in mathematics

YEAR 6/7

test booklet

introduction

The CATIM test is intended to be used by your teacher to find out which parts of your mathematics work you can do well and which parts you cannot.

The test has questions selected from many different parts of the mathematics that you have learned at school.

directions

For all questions on this test 3 or 4 possible answers are given, but only one is correct. You are to choose the answer you think is correct.

The following practice examples will show you how to answer the questions in the test.

Wait until you are told how to answer the questions before going on.

practice examples

- P1 $3 + 4$ equals.
- A 6.
 - B 7.
 - C 8.
 - D 9.

Since $3 + 4 = 7$, B has been written in box P1 on the answer strip.

- P2 Which of these numbers is the smallest?
- A 12
 - B 10
 - C 14
 - D 9

Write the answer you choose in the box P2 on your answer strip. Your teacher will check whether you have written the correct letter before you start the test.

Please do not make any marks in this booklet.

background information for teachers

CATIM is intended to survey the extent to which individuals and class groups have mastered some important aspects of primary mathematics.

To assist in interpretation, pupil data is entered on specially designed *CATIM answer strip sheets*, which can be attached to the *CATIM class analysis chart*. Some interpretation procedures are summarized in the *CATIM manual*.

Further investigation of pupil understanding can be pursued by use of the related *ACER Mathematics Tests (AM Series)*.

The recommended time for the *CATIM test* is about 45 minutes.

- 1 7, 17, 27, 37, —, 57, 67
The missing number is
A 38.
B 47.
C 56.
D 7.
- 2 ★M N O P Q R S
The sixth letter from the star is
A M.
B Q.
C R.
D S.
- 3 Which of these numbers is the largest?
A 507
B 480
C 570
D 488
- 4 Which number comes just after 11 211?
A 11 212
B 21 212
C 11 122
D 22 122
- 5 One more than 84 499 is
A 844 991.
B 84 500.
C 184 499.
D 84 498.
- 6 Which row has its numbers in order of size?
A 275, 752, 725, 572
B 752, 572, 725, 527
C 572, 527, 257, 275
D 752, 725, 275, 257
- 7 The oven tray used for cooking little cakes will hold 25 cakes. The tray was filled 5 times. How many cakes were cooked?
A 5
B 20
C 30
D 125
- 8 At Dick's party 8 boys each ate 9 cakes. Which equation could you use to find the total number of cakes eaten?
A $9 + 8 = \nabla$
B $8 \times 9 = \nabla$
C $\nabla - 9 = 8$
D $9 = \nabla \times 8$
- 9 In which set are all the numbers odd?
A {1, 2, 3, 4, 5, 6}
B {1, 3, 5, 10, 30, 50}
C {21, 37, 41, 57, 61, 77}
D {10, 30, 50, 70, 90, 110}
- 10 Bill had caught 24 fish but 2 out of 3 were too small. They had to be thrown back into the water. How many fish was he able to take home?
A 8
B 12
C 21
D 22
- 11 $(4 \times \square) \times 8$ equals
A $4 + (\square \times 8)$
B $4 \times (\square \times 8)$
C $4 \times (\square + 8)$
D $4 \times (\square - 8)$
- 12 $6\ 876 - 4\ 652 = 2\ 224$
so $2\ 224 \triangle 4\ 652 = 6\ 876$
and $4\ 652 \square 2\ 224 = 6\ 876$
The missing signs are
A \times and \times .
B $-$ and $+$.
C $+$ and $+$.
D $-$ and $-$.
- 13 In this question \square stands for any number greater than one.
 $\square + 8$ is
A equal to eight.
B greater than nine.
C equal to nine.
D less than nine.

In the sentence

$$68 \triangle - 226 = \triangle 58$$

the missing digit shown by the \triangle is

- A 0.
- B 6.
- C 7.
- D 4.

108	78	87		9
112	82	91	8	

The missing numbers are

- A 4 and 5.
- B 4 and 13.
- C 9 and 8.
- D 12 and 13.

Which of the following sets of coins would not give you exactly 40c?

- A 20c, 20c
- B 10c, 10c, 10c, 10c
- C 10c, 5c, 5c, 20c
- D 20c, 20c, 5c

If 2 cricket balls were the same price as 3 tennis balls then

- A a cricket ball is the same price as a tennis ball.
- B a cricket ball is dearer than a tennis ball.
- C a cricket ball is cheaper than a tennis ball.

The coins show the amount of money Jane saves each week.



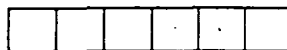
How many weeks will it take her to save \$1.00?

- A 9
- B 10
- C 12
- D 13

- 19 Mary, Jane, and Sally knitted a scarf. Mary knitted $\frac{1}{4}$ and Jane knitted $\frac{1}{3}$ of it. How much did Sally knit?

- A $\frac{1}{4}$
- B $\frac{1}{2}$
- C $\frac{5}{12}$
- D $\frac{3}{4}$

- 20 Which shaded drawing is one third of this figure?



- A
- B
- C
- D

- 21 Which one of the following fractions is larger than $\frac{1}{6}$ and smaller than $\frac{1}{2}$?

- A $\frac{1}{9}$
- B $\frac{1}{12}$
- C $\frac{1}{4}$
- D $\frac{6}{2}$

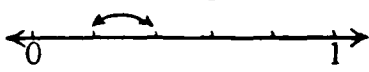
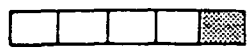


- 22 The fraction which tells about 5 parts of equivalent size is

- A $\frac{4}{5}$.
- B $\frac{1}{4}$.
- C $\frac{5}{4}$.
- D $\frac{3}{4}$.

- 23 Which one of the following is largest?

- A 4.3
- B 4.04
- C 4.005
- D 4.0006

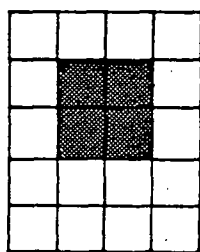
24 Which of the following does not suggest 0.2?

- A 
- B 
- C 
- D 

25 If $\square < 0.63$ and $\triangle < \square$ then

- A $\triangle > 0.63$.
- B $\triangle = 0.63$.
- C $\triangle < 0.63$.

26

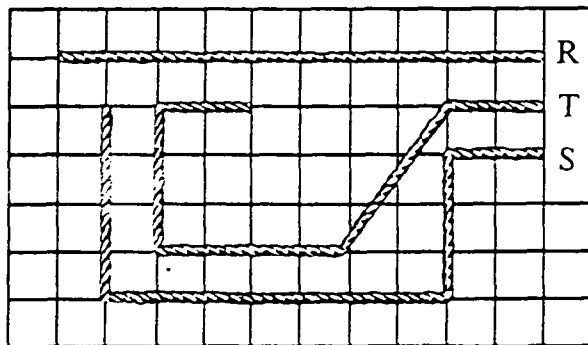


What fraction of the figure is shaded?

- A 0.40
- B 0.04
- C 0.16
- D none of these

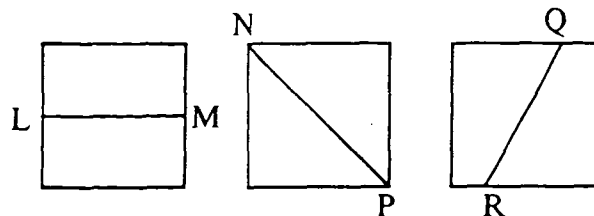
27

The diagram shows three pieces of string. Which piece is the longest?



- A piece R
- B piece S
- C piece T
- D There is no way of telling.

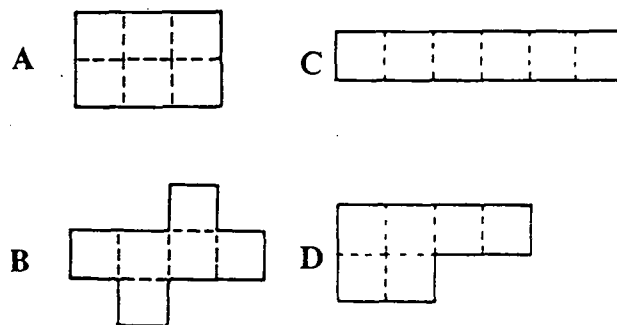
28 Each square is the same size.



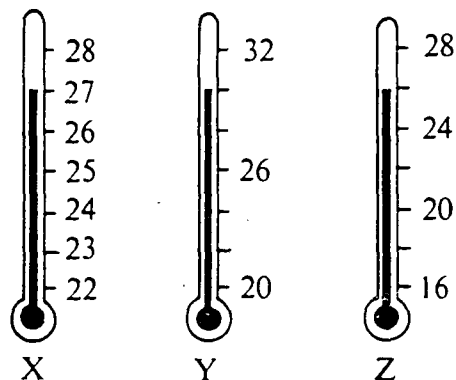
Which line segment is the longest?

- A line segment LM
- B line segment NP
- C line segment QR
- D The line segments are the same length.

29 If these outlines were cut out, which could be used to make a cube when folded only along the dotted lines?

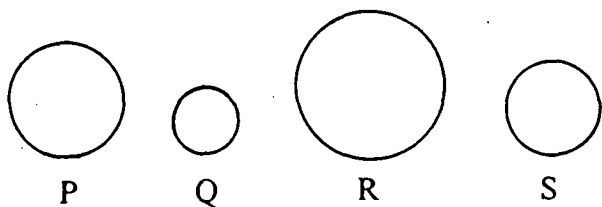


30



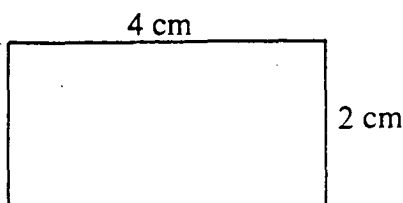
Which thermometer shows the lowest temperature reading?

- A thermometer X
- B thermometer Y
- C thermometer Z



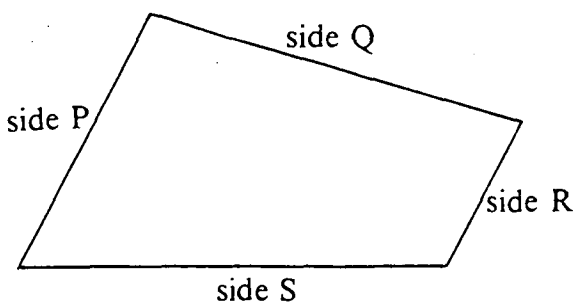
Which circle has the smallest circumference?

- A circle P
- B circle Q.
- C circle R
- D circle S



The perimeter of this shape is

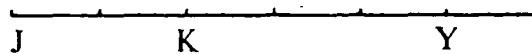
- A 6 centimetres.
- B 8 centimetres.
- C 10 centimetres.
- D 12 centimetres.



To find the perimeter of this shape you

- A multiply the length of side P by the length of side Q.
- B find the total length of side P, side Q, side R and side S.
- C add the length of side P to the length of side Q and double the result.
- D find the total length of the four sides and divide by 4.

34

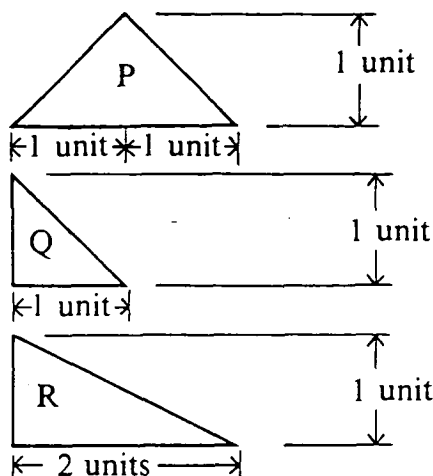


If the distance from J to K is 20 metres, then the distance from K to Y is

- A 20 metres.
- B 25 metres.
- C 30 metres.
- D 40 metres.

35

Look at the areas of the following shapes.



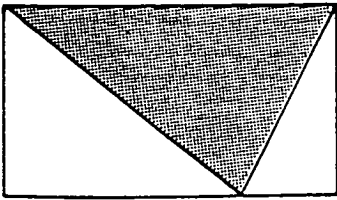
Which shapes have the same area?

- A P and Q only
- B P and R only
- C Q and R only
- D P, Q, and R

36

Which shape is four times as large as ?

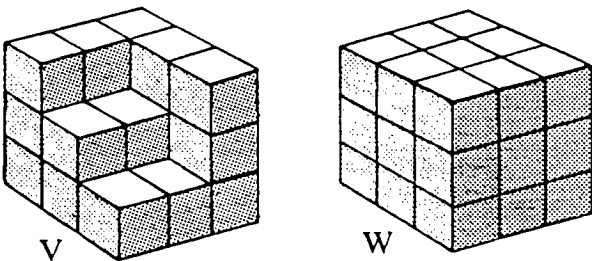
- A
- B
- C
- D



The shaded area represents 3 square metres. What is the area of the rectangle (including the shaded area)?

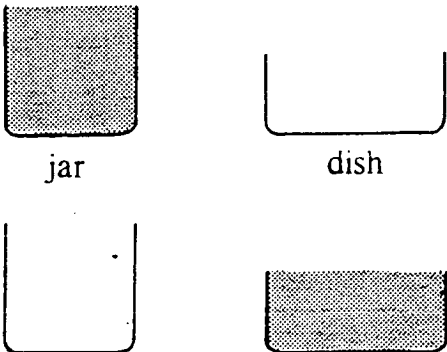
- A 3 square metres
- B 6 square metres
- C 9 square metres
- D 12 square metres

How many more blocks of the same size will be needed to make stack V the same as stack W?



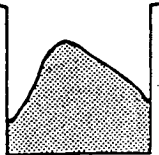
- A 2
- B 4
- C 6
- D 27

All the water is poured from the jar into the dish.

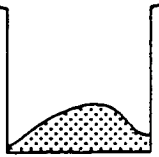


- Which sentence is true?
- A The jar holds more than the dish.
 - B The dish holds more than the jar.
 - C The jar holds the same as the dish.

40 It took this much sawdust to balance a 2-kilogram weight.



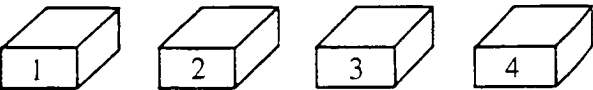
It took this much sand to balance a 2-kilogram weight.



Which one of the following statements is correct?

- A A cup of sand weighs more than a cup of sawdust.
- B A cup of sawdust weighs more than a cup of sand.
- C A cup of sand and a cup of sawdust weigh the same.
- D There is no way of telling.

41 These matchboxes are the same size and contain different amounts of sand. They are placed in order from lightest to heaviest.



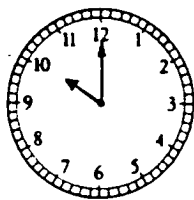
The matchbox with the most sand in it is

- A 1.
- B 2.
- C 3.
- D 4.

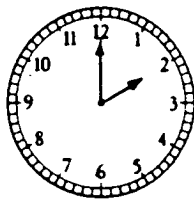
42 Which would be the most appropriate unit to measure the time it takes to boil an egg?

- A an hour
- B a minute
- C a second
- D a day

- 43 When Jill started work in the morning the clock showed this time.



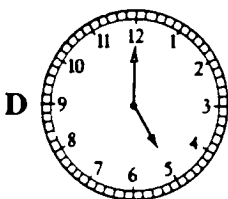
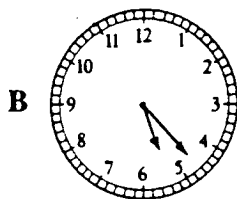
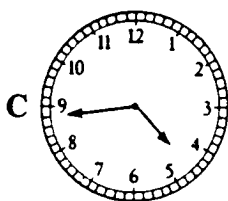
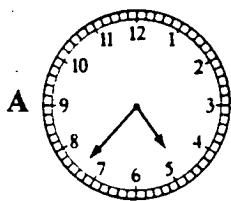
When she finished work that afternoon the clock showed this time.



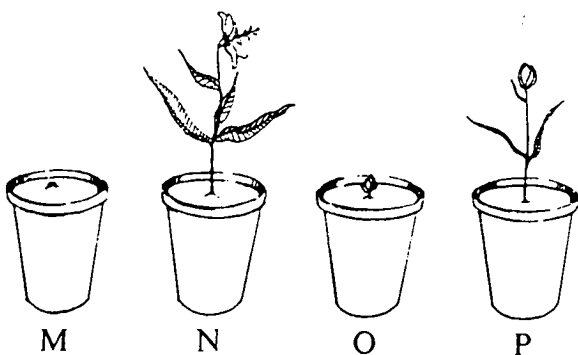
How long did Jill work?

- A 2 hours
- B 4 hours
- C 10 hours
- D 12 hours

- 44 Which clock shows the time as 23 minutes to 5?



- 5 These pictures show planting and stages of growth in a pot plant.



The order of pictures according to growth time should be

- A M N O P.
- B M O N P.
- C M O P N.
- D none of these.

OPERATIONS TEST Test Booklet

Directions

This test booklet contains a total of 60 questions covering a range of mathematical operations met in primary and secondary schools. Students are not expected to do all 60 questions at the one time – your teacher will tell you which ones you are to do.

Each question is a mathematical sentence in which one of the terms has been replaced by \triangle . A question is followed by four alternative answers, labelled A, B, C, and D. You should choose the alternative to replace the \triangle and make the sentence true.

The following practice questions will show you how to answer the questions in the test.

Wait until you are told how to answer the questions before going on.

Practice Questions

P1 $6 + 10 = 6 + \triangle$

A -16 **C** 10

B -10 **D** 16

P2 $5 \times 17 = 5 \times \triangle$

A $\frac{17}{5}$ **C** 17

B 5 **D** 85

Please do not make any marks in this booklet.

BACKGROUND INFORMATION FOR TEACHERS

Test materials in the *ACER Mathematics Profile Series* are designed so that teachers may monitor students' mathematical development throughout primary and secondary schooling. This is achieved by converting raw scores on any of the tests to a common scale called the MAPS scale. Conversion tables for this test are incorporated in the *ACER Mathematics Profile Series — Operations Test Teachers Handbook*. The handbook discusses interpretative procedures concerning the likely mastery of all items on the MAPS scale. These interpretations enable teachers to identify a range of suitable learning experiences, in relation to each student.

To assist in the calculation and use of mastery levels the *answer sheet* has a specially designed student record section and the score key displays a *mastery profile 'cursor'*.

In general, different groups of items in the *Operations* test will be selected for administration, depending on the particular class. The handbook recommends various 30- and 40-item tests and suggests their appropriate year levels. The suggested testing times are

- about 30 minutes for a 30-item test
- about 40 minutes for a 40-item test

1 $3 + 4 = 4 + \Delta$

A 7

C 3

B 5

D -7

2 $7 \times 8 = 8 \times \Delta$

A 56

C $\frac{7}{8}$

B 7

D $\frac{1}{7}$

3 $15 \div 3 = \Delta \div 3$

A 15

C 3

B 5

D $\frac{5}{3}$

4 $6 \times 1 = \Delta$

A 61

C 6

B 7

D 1

5 $(3 \times 2) \times 5 = \Delta \times (2 \times 5)$

A 15

C 3

B 6

D $\frac{1}{3}$

6 $5 - 2 = \Delta - 2$

A 5

C 1

B 3

D -5

7 $5 + 0 = \Delta$

A 6

C 0

B 5

D -5

8 $(5 + 4) + 6 = \Delta + (4 + 6)$

A 15

C 6

B 9

D 5

9 $9 + 1 = \Delta$

A 91

C 9

B 10

D -8

10 $8 \times 0 = \Delta$

A 80

C 1

B 8

D 0

11 $(8 - 4) + 4 = \Delta$

A 12

C 4

B 8

D 0

12 $(12 \div 2) \times 2 = \Delta$

A 12

C 3

B 6

D $\frac{1}{12}$

13 $15 \div 5 = 30 \div \Delta$

A 15

C 3

B 10

D 2

14 $4 + 5 = (4 + 6) + (5 + \Delta)$

A 6

C -1

B 4

D -6

15 $7 - 4 = \Delta - 7$

A 11

C 4

B 10

D 3

16 $8 \div 4 = \Delta \div 8$

A 32

C 4

B 16

D 2

17 $(7 \times 2) - (3 \times 2) = (7 + \Delta) \times 2$

A 4

C -3

B 3

D -4

18 $(24 \div 6) \div 2 = \Delta \div (6 \div 2)$

A 24

C 6

B 12

D 4

19 $(12 - 6) - 4 = \Delta - (6 - 4)$

A 12

C 4

B 8

D 2

20 $(40 \div 8) \times 4 = (40 \times 4) \div (\Delta \times 4)$

A 32

C 4

B 8

D 2

21 $123 + 456 = 456 + \Delta$

A 579 C - 123

B 123 D - 333

22 $44 \times 125 = 125 \times \Delta$

A 5500 C 44

B 125 D $\frac{125}{44}$

23 $864 \div 432 = \Delta \div 432$

A 864 C 2

B 222 D $\frac{1}{2}$

24 $984 \times 1 = \Delta$

A 9841 C 984

B 985 D 1

25 $(23 \times 24) \times 25 = \Delta \times (24 \times 25)$

A 23×25 C $\frac{23}{25}$

B 23 D $\frac{1}{23}$

26 $654 - 543 = \Delta - 543$

A 6003 C 111

B 654 D - 432

27 $876 + 0 = \Delta$

A 8760 C 876

B 877 D 0

28 $(89 + 67) + 33 = \Delta + (67 + 33)$

A 122 C - 89

B 89 D - 156

29 $578 + 1 = \Delta$

A 579 C 577

B 578 D 1

30 $769 \times 0 = \Delta$

A 7690 C 769

B 770 D 0

$$31 \quad (987 - 321) + 321 = \Delta$$

A 987 C 345

B 666 D 321

$$32 \quad (625 \div 25) \times 25 = \Delta$$

A 625 C 25

B 125 D 1

$$33 \quad 240 \div 15 = 480 \div \Delta$$

A 30 C $\frac{15}{2}$

B 16 D $\frac{2}{15}$

$$34 \quad 123 + 456 = (123 + 789) + (456 + \Delta)$$

A 789 C -123

B 123 D -789

$$35 \quad 654 - 543 = \Delta - 654$$

A 1197 C 543

B 765 D 111

$$36 \quad 468 \div 234 = \Delta \div 468$$

A 936 C 117

B 234 D $\frac{1}{234}$

$$37 \quad (72 \times 25) - (60 \times 25) = (72 + \Delta) \times 25$$

A 60 C -12

B 12 D -60

$$38 \quad (900 \div 30) \div 10 = \Delta \div (30 \div 10)$$

A 900 C 30

B 90 D 9

$$39 \quad (89 - 56) - 21 = \Delta - (56 - 21)$$

A 110 C 68

B 89 D 47

$$40 \quad (72 \div 36) \times 9 = (72 \times 9) \div (\Delta \times 9)$$

A 324 C 4

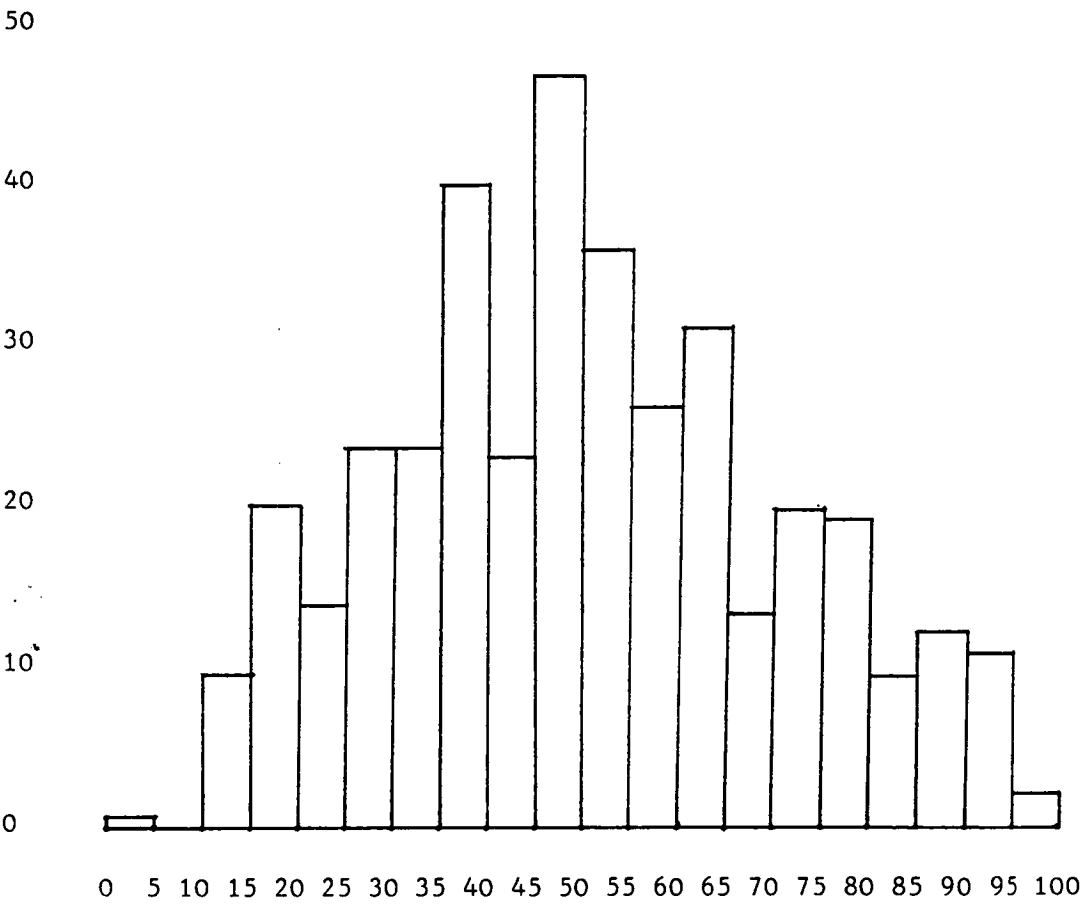
B 36 D 2

APPENDIX II

Frequency Histograms and Descriptive Statistics
for Variables Employed in the Study

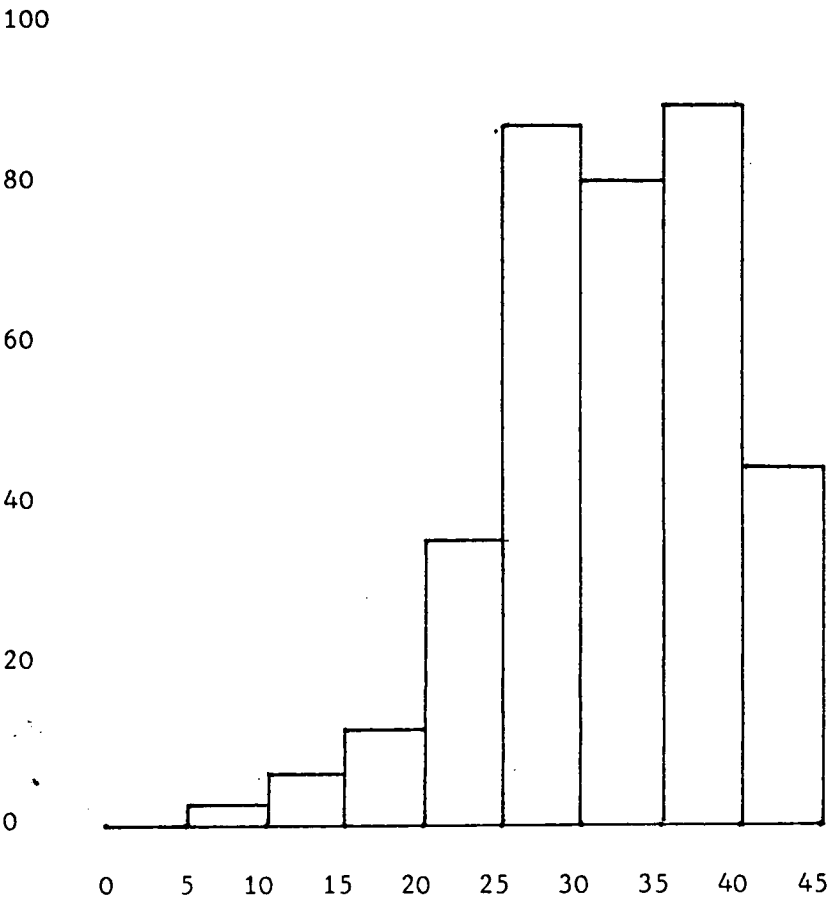
(All Cases)

Grade Seven Mathematics Achievement (CMAT)



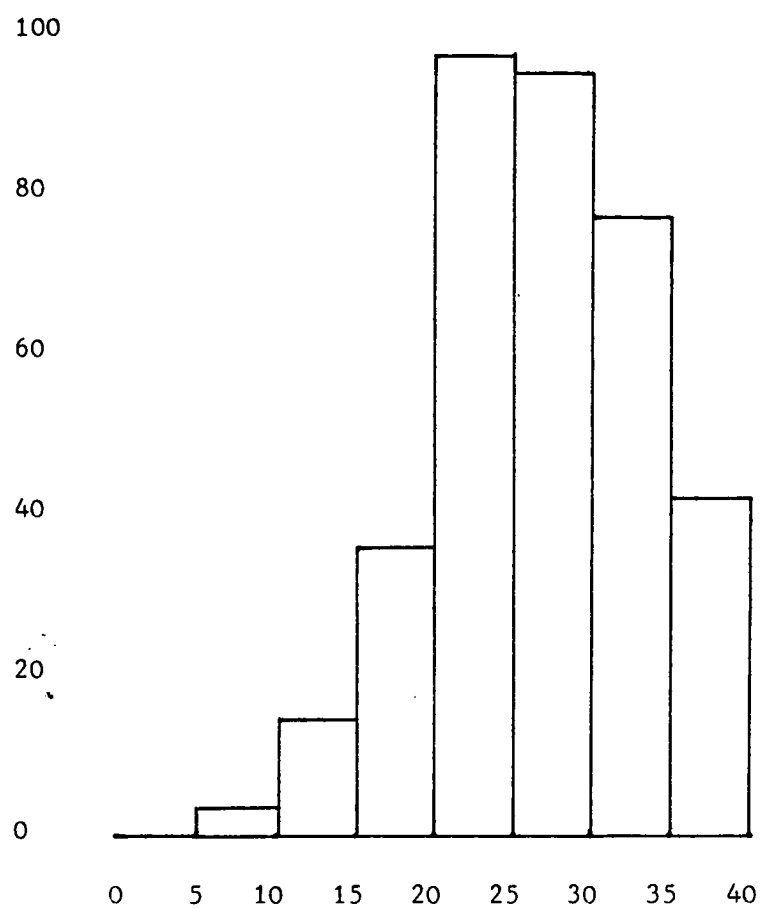
Mean = 48.79 Mode = 45.00 Median = 47.83
Kurtosis = -0.53 Skewness = 0.22

Upper-Primary School Mathematics Achievement (MACH)



Mean = 31.64 Mode = 36.00 Median = 32.26

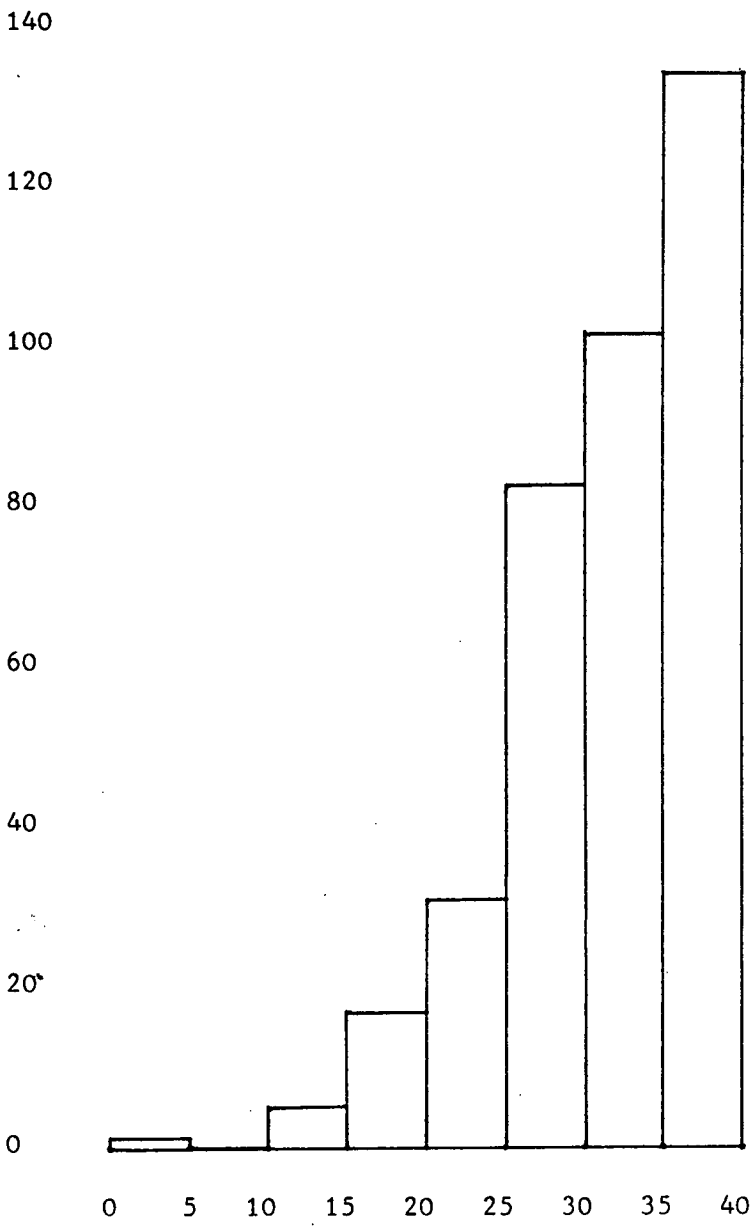
Kurtosis = 0.35 Skewness = -0.62

Mathematics Aptitude (MAPT)

Mean = 26.17 Mode = 24.00 Median = 26.11

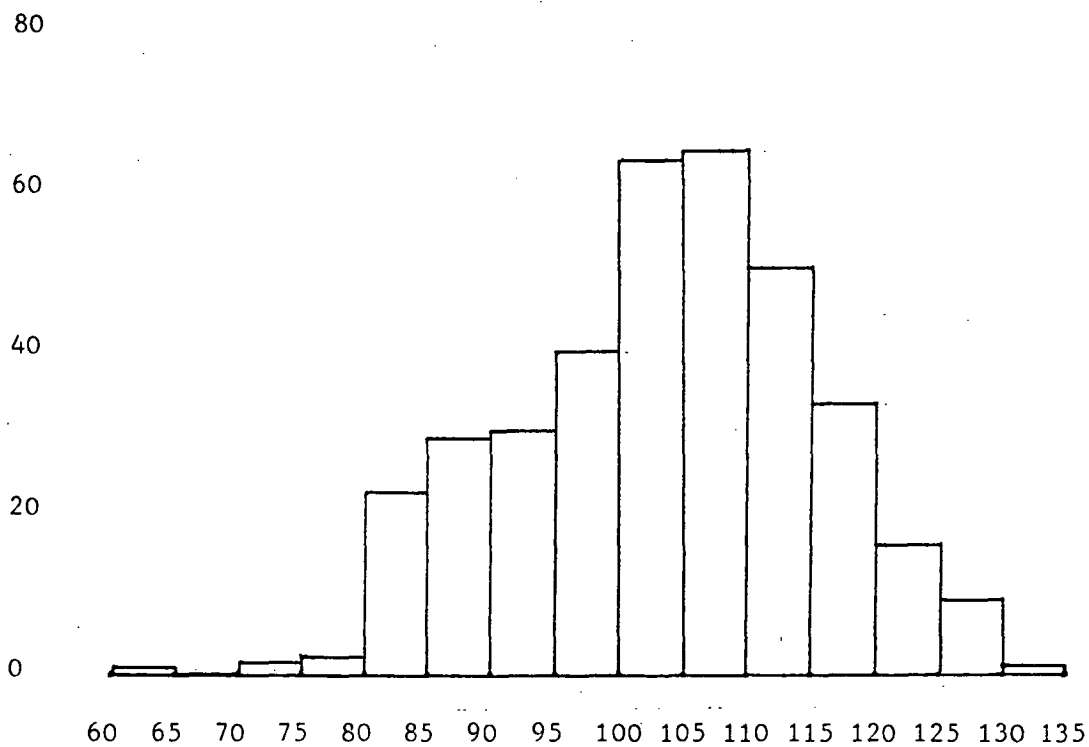
Kurtosis = -0.14 Skewness = -0.30

Reading Comprehension (RCOM)



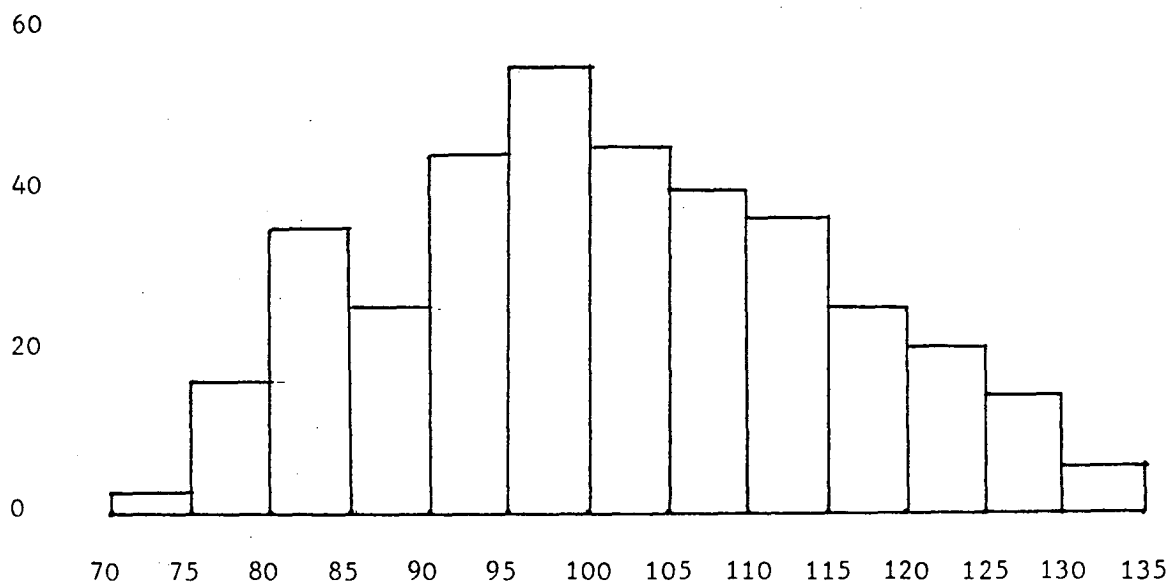
Mean = 30.52 Mode = 37.00 Median = 31.98
Kurtosis = 0.94 Skewness = -1.07

Non-Verbal I.Q. (NVIQ)



Mean = 102.88 Mode = 106.00 Median = 103.93

Kurtosis = -0.24 Skewness = -0.19

Verbal I.Q. (VIQ)

Mean = 100.71 Mode = 83.00 Median = 99.58

Kurtosis = -0.65 Skewness = 0.24

APPENDIX III

Scatterplots of the Criterion Plotted Against

- Upper-Primary School Mathematics Achievement MACH
- Mathematics Aptitude MAPT
- Reading Comprehension RCOM
- Non-Verbal I.Q.
- Verbal I.Q.

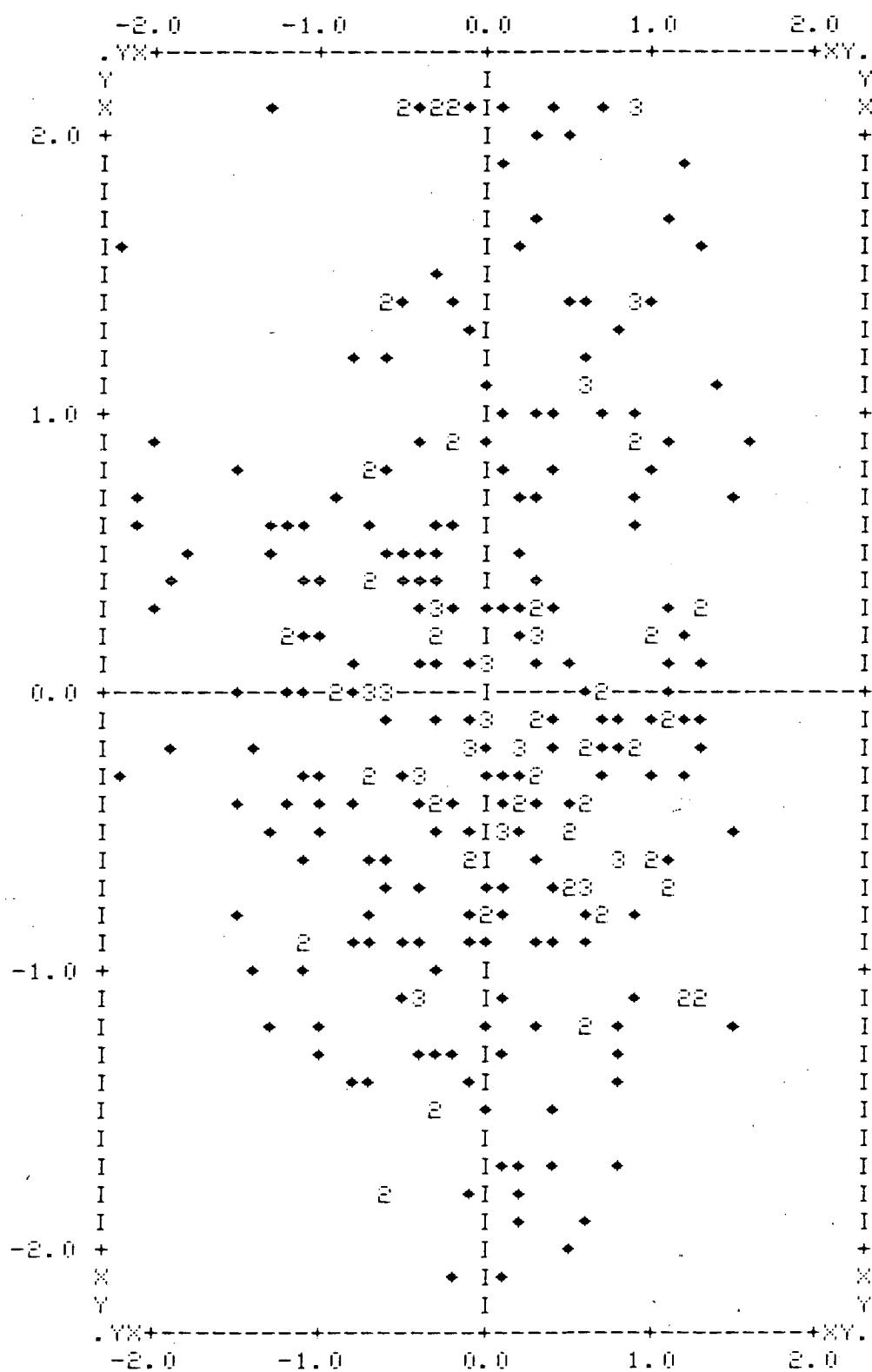
CMAT and RCOM

[illegible]

APPENDIX IVScatterplots of Residuals

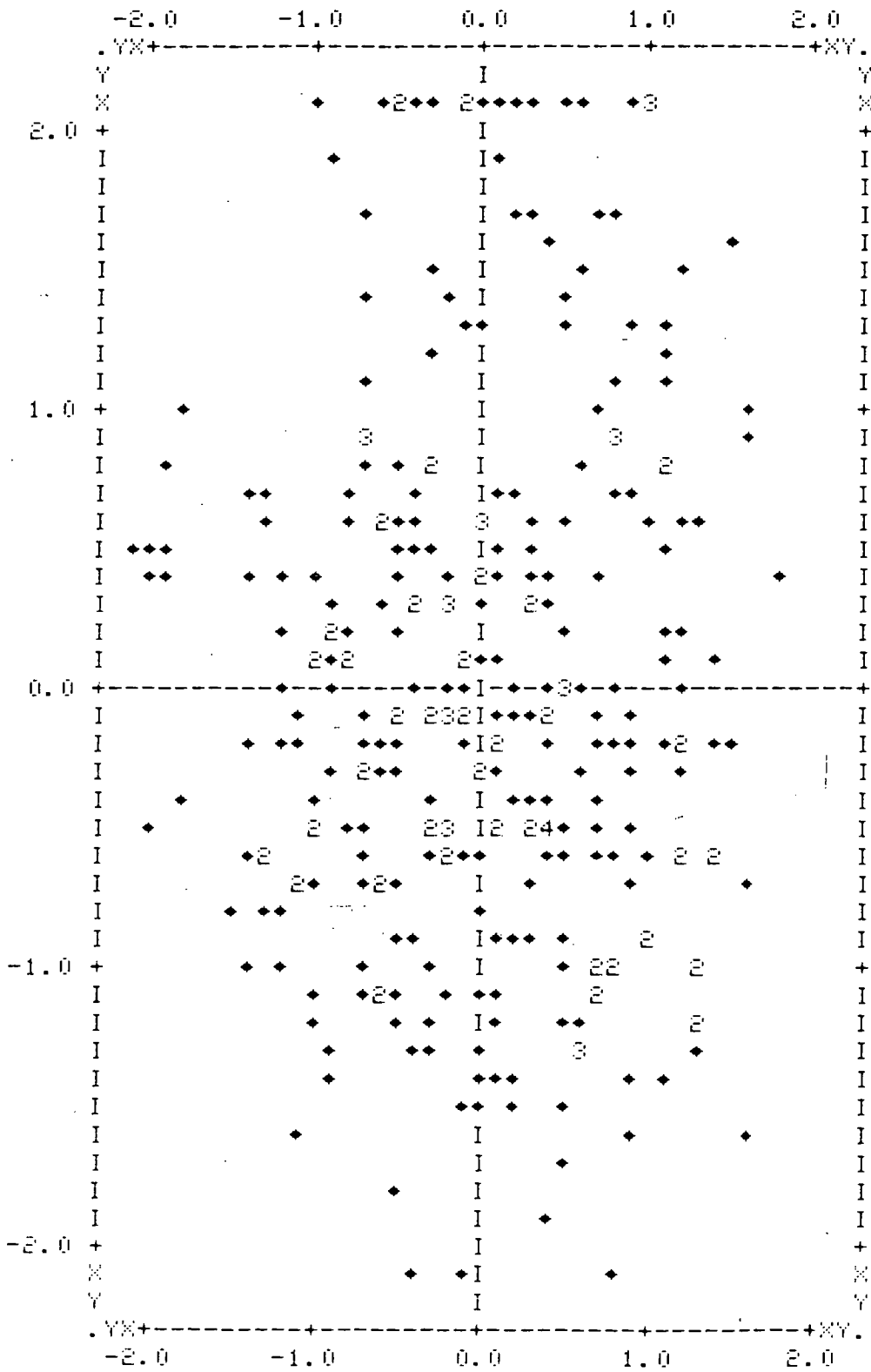
Standardised Residuals (DOWN). CMAT (ACROSS)

Independent Variables - MAPT, MACH



Standardised Residuals (DOWN) CMAT (ACROSS)

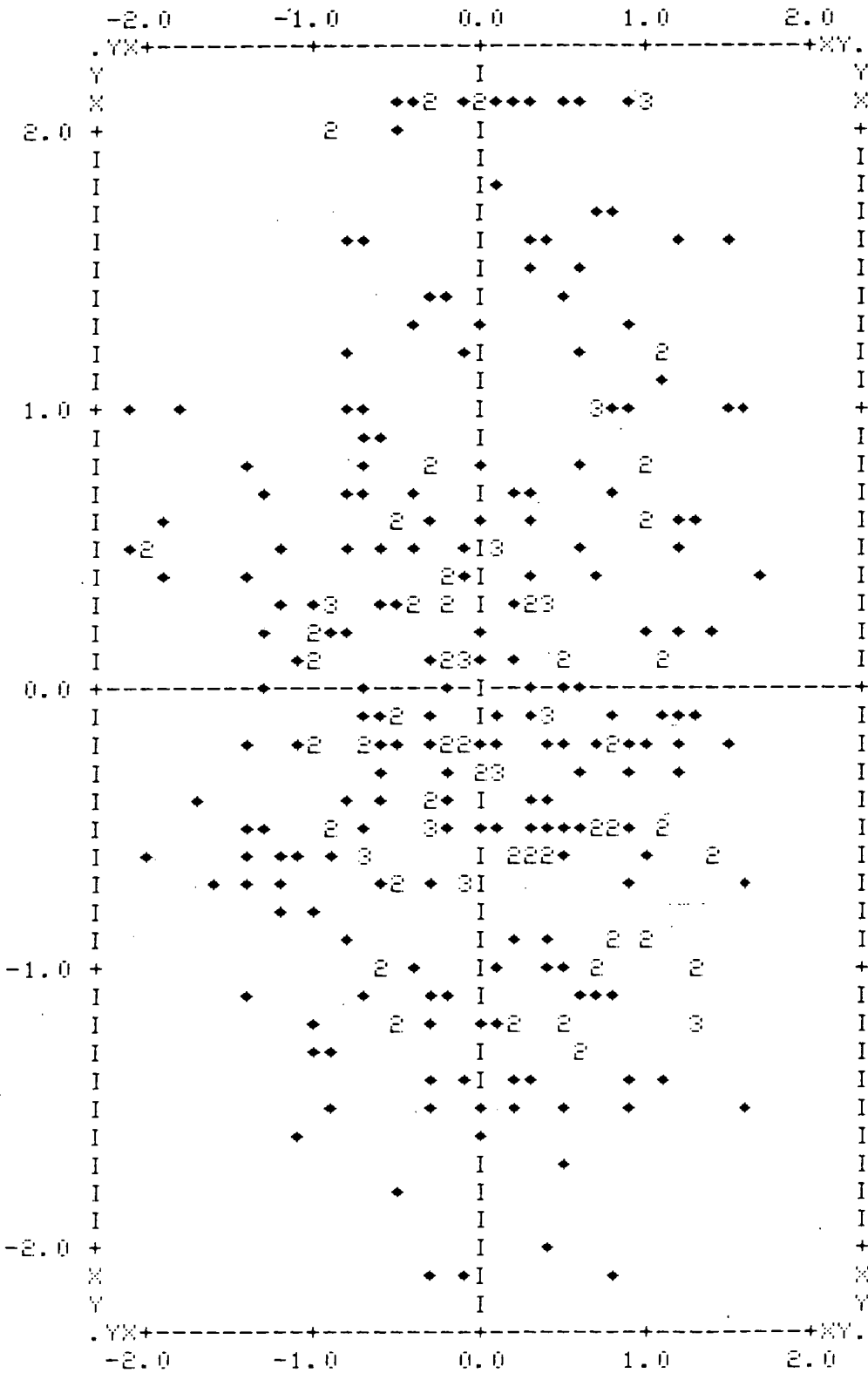
Independent Variables - MAPT, MACH, NVIQ, VIQ



Standardised Residuals (DOWN)

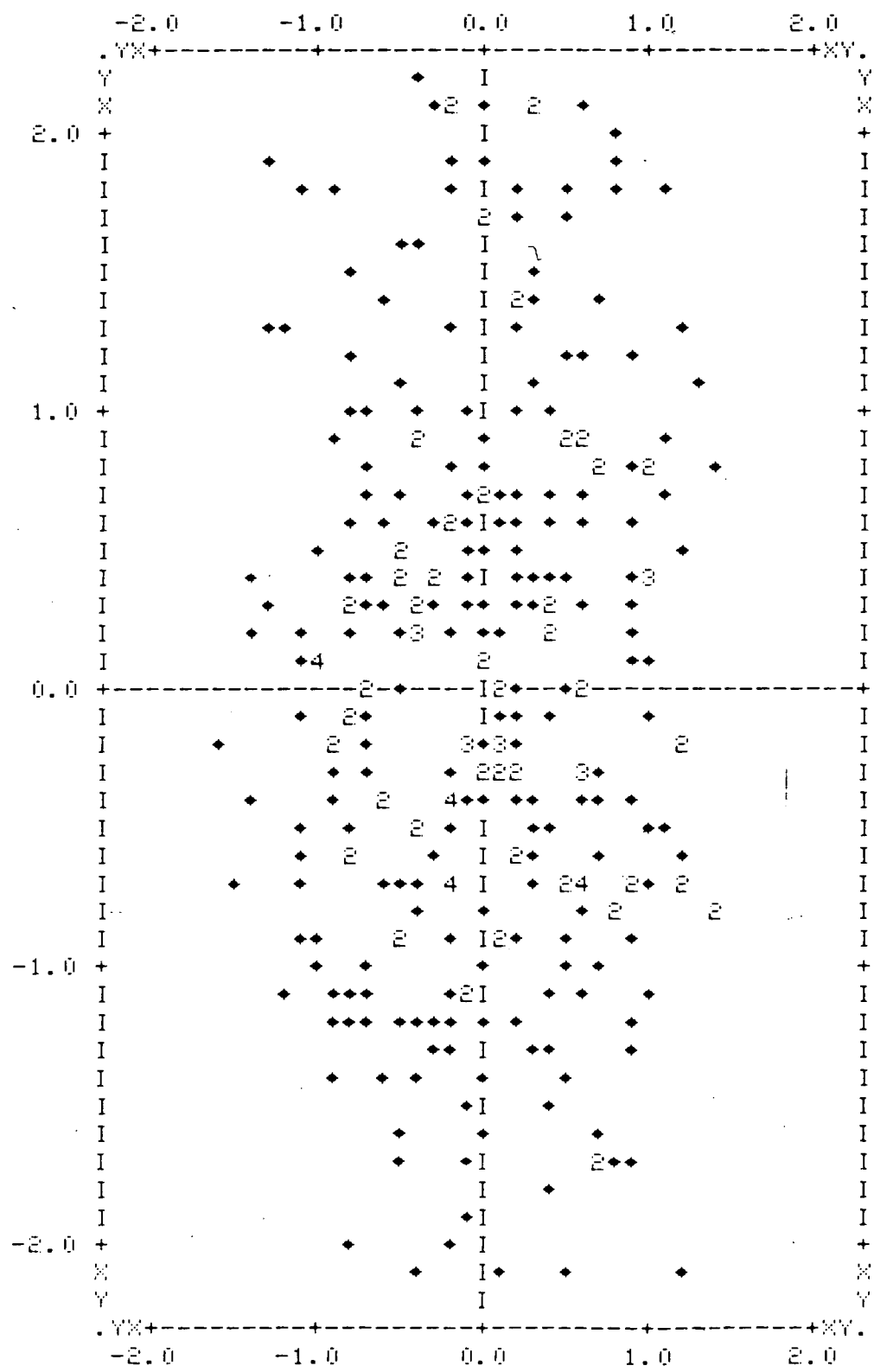
CMAT (ACROSS)

Independent Variables - MAPT, MACH, NVIQ, VIQ, RCOM



Standardised Residuals (DOWN) CMAT (ACROSS)

Independent Variables - NVIQ, VIQ



Standardised Residuals (DOWN) CMAT (ACROSS)

Independent Variables - VIQ, RCOM

